

UNIVERSITY OF BRISTOL



THE ANNUAL REPORT

OF THE

Agricultural and Horticultural
Research Station

(THE NATIONAL FRUIT AND CIDER INSTITUTE)

LONG ASHTON, BRISTOL
1942

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INTRODUCTION.

By B. T. P. BARKER, M.A., Director.

During the period covered by the present Annual Report the war has reached its fourth year. With each successive year the need for increased food production in the British Isles has grown more urgent and greater efforts have been required both from all classes of growers and from those concerned with the educational, advisory and research aspects of the subject. Therefore, as this Report shows, the Department of Agriculture and Horticulture of the University has intensified its work in these directions. As regards research in particular, it has been obliged to subordinate even more drastically than in the earlier years of the war its normal peace-time long-distance investigations to the study of current problems of pressing importance offering promise of quick results of practical application.

Its collaboration in the work of the County War Agricultural Executive Committees of the Bristol Advisory Province and their newly-formed Technical Development Sub-Committees has become most active and has brought its technical staff into still closer personal touch with the respective County schemes to help farmers and, also, with individual growers themselves and their problems.

Similarly, in several of the wider national projects of the Ministry of Agriculture and Fisheries and other Ministries and Government bodies the Department and individual members of the staff have been called upon to give assistance in greater measure than previously. In some instances additions to the staff have been necessary: in other cases either the members of the staff concerned have been seconded to a Government or County Department or have been obliged to give a substantial part of their time to such special work. Extra workers have also been engaged to press on more rapidly and on an increased scale with investigations of special urgency or promise.

Notwithstanding these special calls some of the younger members of the staff have been released for service in the Forces, while most of the remaining staff are assisting in one or other of the Home Defence Services.

The Field Laboratory at Evesham, established in 1941 to provide a working centre for members of the research and advisory staffs in the heart of the market garden industry in that important area, has already justified its existence. The two workers regularly stationed there have been very fully occupied in studying the local problems of the growers and their help and advice has been continuously in demand. The limited accommodation originally provided soon became overcrowded and it has been found necessary to add a small annexe to the building. During the course of the summer the Luxmoore Committee, appointed by the Minister of Agriculture to review the existing system of Agricultural Education in this country and to make recommendations for its improvement, visited this Field Station as well as the Advisory Centre at Bristol and the Long Ashton Research Station.

At each of these working centres of the Department as well as at the Campden Research Station, which is also attached to it, good progress can be reported for the year. The financial position has been strengthened, the number and amount of subscriptions increased and the interest in its work

considerably widened. The number of advisory enquiries received and dealt with has exceeded by a large margin the highest figure hitherto recorded. Details of the work at Bristol and Long Ashton, so far as they can be published at present, will be found in the following pages, the corresponding information for the Campden Station being given in its own Annual Report issued separately.

BRISTOL AGRICULTURAL ADVISORY CENTRE.

Supplementing the abbreviated account of the Advisory work for the year given later in this Report, it may be recorded here that grants have been received for four new schemes to be undertaken by the Centre, viz., the National Farm Survey, the National Milk Testing and Advisory Scheme, an Experimental Survey of Fertiliser Practice and an Enterprise Cost Enquiry.

Attention should also be called to the considerable development which has taken place in connection with the Wireworm Survey. The Ministry of Agriculture having decided that this Survey should be intensified throughout the Province, provision has been made for five teams of field workers instead of the single team hitherto employed. Thus it is now possible to maintain simultaneously in each of the five counties constituting the Bristol Advisory Province a team continuously engaged on the survey. This extension has been associated with the appointment of Dr. H. W. Miles, as Advisory Entomologist, under whose charge the general direction of the Survey has been placed. Dr. Miles and his co-workers are stationed at Long Ashton as their headquarters, in accordance with the standing arrangement under which the Plant Pathology officers of the Advisory staff work there in conjunction with the Plant Pathology Research staff of that Station.

Staff.

The appointment of Dr. Miles as Advisory Entomologist followed the retirement of Dr. C. L. Walton from this post at the end of July under the superannuation regulations. Dr. Walton had been in the service of the Department for 15 years, having originally been appointed as Research Entomologist. Following his serious illness in 1931, he was transferred to the Advisory staff, Dr. H. G. H. Kearns taking over the Entomological Research post thus vacated. As Advisory Entomologist he will be remembered in particular for his valuable contribution in introducing into the Province the use of derris preparations for the control of Warble Fly.

Apart from this change, the senior staff remains unaltered. There have been many additions to the assistant staff resulting from the fresh schemes of work which the Centre has undertaken. Details of these are given in the list of staff changes appended to the Report on Advisory Work for the year on page 156.

Owing to the prolonged illness of Miss Burnett, Administrative Secretary at the Advisory Centre Offices at Bristol, temporary re-arrangements in the office staff have been necessitated.

Buildings.

Reference was made in the Annual Report for 1941 to the need for additional accommodation. This has now been met by the provision of separate offices at 79, Woodland Road, Bristol, for the Agricultural Economics Section of the staff, these quarters having been offered to the Centre by the University.

LONG ASHTON RESEARCH STATION.

Staff.

During the year an abnormal number of staff changes have occurred as a result of war-time needs and conditions.

Mr. V. E. Sills, attached to the Cider and Fruit Products Section, has joined the Fleet Air Arm. Assistance in the microbiological work associated with his post is being given by Dr. A. H. Campbell, B.Sc., Ph.D., Lecturer in that subject in the Department of Botany at Bristol University. The Station is indebted to Professor Skene, Head of that Department, for his offer to spare Dr. Campbell's services for part-time work for this purpose.

Mr. D. P. Hopkins, also a member of the Fruit Products Section, has accepted a post with a commercial firm. Various changes in personnel of the Fruit Products staff have been necessitated by his departure and that of Mr. Sills. Miss Kieser, the analytical chemist on that staff, has taken over the chemical work which Mr. Sills had in hand, and Mrs. J. Steedman, B.Sc., and Miss Tapper have been appointed as Assistant Analysts. Mr. L. F. Burroughs, B.Sc., has been appointed for the processing work for which Mr. Hopkins had previously been responsible.

Associated with the considerable expansion of the work of Dr. Wallace and his colleagues on Mineral Deficiencies of Crops, several staff changes have taken place. Dr. W. Plant, formerly Assistant in General Chemistry, has been delegated to make a survey of Minor Mineral Deficiencies of Crops for the Agricultural Research Council. The post which he has vacated for these new duties has been filled by the appointment of Mr. J. C. Todd, B.Sc. Dr. W. E. Berry, the Plant Physiologist at the Station, who normally would have been responsible for the physiological side of these extended investigations, has been seconded to the Ministry of Aircraft Production for the duration of the war. His place in this work has been taken by two new assistants, Mr. E. J. Hewitt, B.Sc., and Mr. D. J. Nicholas, B.Sc.

Illness has caused some interference with the research work in various Sections, both Mr. R. W. Marsh and Mr. G. T. Spinks having been granted periods of sick leave to undergo operations, while other individual members of the staff have been absent for shorter periods.

Buildings and Land.

The building alterations referred to in last year's Report to provide for the new Home Kitchen were completed early in the year, since when these quarters have been in active use for special Courses for teachers and students and other purposes. It was found possible, also, to hold in them the usual Summer Courses for students, thus obviating the need to make the special arrangements at an outside Centre hitherto required. The space freed in the main laboratory building by this new accommodation has been refitted and equipped to serve as a laboratory for research work on the Domestic Preservation of Fruit and Vegetables.

The alterations to the range of farm buildings to provide room under cover for the housing of tractors and other farm machines and implements have been nearly completed. The repair workshops have been well equipped with the necessary machines and tools, and the Station is thus now able to carry out, under the general direction of Dr. Kearns, the major part of the

repair work required for implements, tractors and other motor vehicles.

In the last Annual Report reference was made to an impending change in policy respecting that part of the land on the Station farm not already reserved for the fruit and vegetable work. Owing to orders received from the County War Executive Committee to plough a large part of the area in question for the production of agricultural crops and the impossibility of undertaking additional work of this type with the labour and equipment available, it was decided to let the whole of that area. Arrangements have been completed for its lease to the tenant of an adjoining farm.

There are no changes of note to report as regards the land retained by the Station for use in connection with its fruit and vegetable investigations. Special endeavour has been made to increase food production on this area by every possible means and a considerable proportion has been cropped with vegetables. This has afforded opportunities for the further study of nutritional requirements of individual crops and the investigations on mineral deficiencies.

Research Activities.

Every effort has been made to ensure that the results of recent research on crop production and allied subjects have been brought promptly into practical application in the campaign for increased food production, especially in matters concerning fertiliser practice, mineral nutritional deficiencies and the control of crop diseases and pests. Local demonstration and experimental centres in connection with these subjects have been organised in collaboration with the respective County staffs, both in the Bristol Province and in other parts of the country.

In connection with this work the researches of Dr. Wallace and his colleagues on crop failures due to mineral deficiencies have been extended considerably; while, to assist in the campaign for the control of diseases and pests, Dr. Kearns and his staff during the summer of 1942 gave short courses of training in the methods of operation of mobile power spraying machines and the use of modern forms of spray fluids to fifty members of the Women's Land Army. Teams of the latter are being employed by various County War Agricultural Executive Committees for contract spraying and the training of further units is proceeding continuously.

In the Fruit Products Section the work on black currant and rose hip syrups referred to in last year's Report has been continued under the supervision of Mr. Charley. The utilisation of surplus carrots for conversion into useful food products was investigated and a large tonnage of the surplus from the 1941 crop was processed by commercial firms, the whole output being quickly disposed of and a heavy demand in excess of available supplies remaining unsatisfied. Arrangements also were made to preserve a considerable tonnage of the abnormally large plum crop of 1942 by the Long Ashton cold-process sulphur dioxide method. The whole of this work was undertaken in conjunction with the Ministries of Agriculture, Food and Health.

Miss Crang and her staff in the Domestic Preservation of Fruit and Vegetables Section have collaborated again with the Ministries of Agriculture and Food and the Federation of Women's Institutes during the summer of 1942 in the work of the local Fruit Preserving Centres established throughout the country. Additional courses of instruction for teachers in the subject

and for those associated with the operation of these Centres have been given by the Staff.

Annual Field Day. As in the previous years of the war, it was considered desirable to suspend the Annual Tasting Day. Subscribers to the Institute, however, were provided with an opportunity to see current work in progress on the occasion of the Annual Meeting of the National Fruit and Cider Institute, which was held at the Station on June 29th.

Visitors. Although the number of individual visitors to the Station still continues to be less than during normal pre-war years, many have come to consult members of the staff on various problems and on special matters relating to one or other branch of the work.

During the latter part of the summer Dr. W. W. C. Topley, F.R.S., Secretary of the Agricultural Research Council. Mr. E. H. E. Havelock, C.B.E., Administrative Secretary of the Council, and Mr. H. Biggs, of His Majesty's Treasury, visited the Station and various centres in Wiltshire and the neighbourhood of Bristol to inspect the results of the manurial trials concerned with mineral deficiencies of various crops which Dr. Wallace was conducting at those centres. As a direct result of their visits arrangements immediately were made for a considerable extension of this work under special grants provided by the Agricultural Research Council. The staff additions associated therewith have been referred to above.

As a further result of Dr. Topley's visit arrangements were made through the War Executive and Agricultural Education Committees of the counties of the Bristol Province for the staffs of those bodies and their District Executive Officers to attend a demonstration of the mineral deficiency work in progress at Long Ashton and in the neighbourhood. Invitations also were sent to representatives of the Ministry of Agriculture and the Fertiliser Control. Two days, August 11th and 13th, were set aside for this purpose and a gratifying attendance of keenly interested visitors was secured on each occasion.

Apart from these special parties the number of organised parties received at the Station during the year has shown an increase on that of the previous year. The list is as follows :—

- Fishponds Diocesan Training College.
- King's College (London) Chemical Society (2).
- King's College (London) Botanical Society.
- Southlands College, Weston-super-Mare.
- Ministry of Agriculture and Fisheries Inspectors.
- Luxmoore Committee on Agricultural Education.
- Association of Scientific Workers.
- Reading University Final Degree and Diploma Students.
- S.E. Essex Technical College.
- Walton Bay Women's Voluntary Service and Women's Institute.
- Wiltshire County Council Education Department.
- Upton Cheyney Women's Institute.
- Bishop Road Gardening School (Bristol).
- Almondsbury and Hallen Women's Institute.
- Bristol Tramways and Carriage Company Allotment Holders.
- Pilning and Northwick Women's Institute.
- Pharmacy Students Association.
- Domestic Science College, Bath.

Shows. The exhibits provided by the Station at various Shows and Exhibitions during the year have been concerned entirely with the "Dig for Victory" campaign. In their character the exhibits were designed specially

to demonstrate to small growers, allotment holders and those with private gardens how some of the more important problems in vegetable culture can be overcome. The following is a list of places to which exhibits were sent :—

Bristol (4)	Gloucester
Bath (2)	Hereford
Cannington	Madresfield
Cheltenham (2)	Malvern
Cirencester	Minehead
Frome	

Research Students and Voluntary Workers. Mr. A. F. Parker-Rhodes, B.A., has been the only voluntary research worker engaged on investigations at the Station during the year. He has continued his research on the mode of action of various fungicides.

The Station has again received valuable help in the work in the fruit plantations from parties of scholars from Clifton College, Clifton High School for Girls, Colston Girls' School and the Red Maids' School as well as Girl Guides from West Bristol. Grateful acknowledgment is made of the help given by them during the course of their summer holidays.

To Mr. J. E. Bevis, also, the thanks of the Station are due for his voluntary help in the practical and recording side of the fruit plantations work throughout the year.

Acknowledgments.

In addition to the acknowledgments already made, the indebtedness of the Department to the many growers, industrial firms and other organisations and persons—too numerous to name individually—who have assisted it in various ways during the year must be recorded. Whether in the form of direct financial support, of personal collaboration in the experimental work and surveys in progress, of the provision of facilities for field trials, factory tests and other operations, or of special technical advice and experience, the help given by them has contributed very materially to the advancement of its work. The willing manner and ready co-operation with which such aid has been given have been particularly appreciated and have contributed in no small degree to the success achieved.

To the staff of all grades is tendered the warmest personal thanks for their support during a year throughout which working conditions have been difficult and the accumulating strain of additional duties of various forms of National Service has been manifest.

THE PRODUCTION OF CIDER FRUIT ON BUSH TREES.

PROGRESS REPORT, 1942.

By T. SWARBRICK.

A progress report on the size and cropping of cider varieties growing as bush trees at a number of county centres was published in the Annual Report for 1941, p. 11. The present report deals with the 1942 crop of these trees and a large block of similarly aged trees growing at the Long Ashton Research Station. The trees were all planted in the winter of 1935—36 and had thus been established six years when the 1942 yield data were obtained. The work in 1942 was carried out jointly with the Cider Section, who made the first of a series of proposed tests on the vintage quality of the fruit produced under the differing conditions of soil, climate and culture, etc.

It should be pointed out that this trial consists of two parts. At Long Ashton there are four varieties, viz. : Sweet Alford, Dabinett, Knotted Kernel and Stoke Red, on the three rootstocks, Crab, M I, and M IX. Of the trees on M I and Crab, some have short stems, approximately 2' 0" long, whereas the others have stems approximately 4' 6" long. The trees are planted in groups of 12, and the minimum number of trees of any one combination is 36. The trees in the county centres comprise "variety trials," in which there are five trees of ten varieties growing on the two rootstocks M I and Crab. (Ann. Rept. Long Ashton Res. Stat. 1941, p. 11.)

A standard planting distance of 20' x 20' was adopted throughout for the trees on M I and Crab. At Long Ashton the permanent trees (20' x 20') have been interplanted in one direction with "filler trees" on M IX at ten feet apart. An interplant of black currant bushes completes the scheme. Clean cultivation is maintained so that in fact the cultural conditions and general management resemble those which prevail in the early years of many commercial fruit plantations. The cultural conditions in the county centres vary, depending upon local customs and the general practice of the grower. In no case have the trees at the county centres been interplanted with either filler trees or bush fruits. At one centre (Faversham) completely clean cultivation has been maintained, but at the others crops such as potatoes, swedes, mangolds and in one case pedigree grasses have been grown in the alleyways, leaving the trees in narrow grass strips which may or may not be mown.

Results.

The crop yields are given as tons per acre, since this is the basis upon which the commercial grower calculates the economics of fruit growing. A planting distance of 20' x 20' gives 110 trees per acre completely planted. This is a useful number because a yield of one pound per tree is only two pounds short of 1 cwt. per acre. For practical purposes, therefore, the mean yield per tree in lb. gives the yield per acre in cwt. The yields given in Tables I and II have been calculated in this way. At Long Ashton the yields per acre

are based on the mean yield of not less than 36 trees. The yields for the county centres represent the mean yields of five trees on each rootstock. Naturally with only five trees from which to calculate the average, the result is not so reliable, since one tree cropping heavily or lightly has a large effect upon the average.

I. Long Ashton Trial.

(a) *Variety.* Of the four varieties included in the Long Ashton trial only Sweet Alford and Dabinett have as yet yielded crops. Dabinett is outstanding with a yield varying between 15 cwt. and 2 tons per acre depending upon rootstock. This variety also produced a crop of about 10 cwt. per acre in 1941. Sweet Alford has produced from 10 cwt. to 1 ton 17 cwt. per acre. The remaining two varieties, Knotted Kernel and Stoke Red have not cropped except for a few fruits on the trees on M IX. The tardy cropping of these two varieties is well known and they were included with the express purpose of observing the influence of rootstock and cultural conditions upon this particular characteristic. The vintage variety Kingston Black, although only represented by about 20 trees in this trial, has given a yield of from 12 cwt. to 1 ton per acre, which must be regarded as satisfactory.

(b) *Rootstock.* Three rootstocks M I, Crab, and M IX, are under investigation. The data given in Table I show no consistent difference in yield between trees on the two rootstocks M I and Crab. Sweet Alford on M I has been more productive than on Crab, but with Dabinett the trees on Crab have given the better crops. This point will be dealt with again later when discussing the yields from the county trials. The characteristic effect of M I upon the growth habit of these trees is clearly visible.

The effect of the rootstock M IX is characteristic. The trees of Sweet Alford on M IX have given a mean yield per tree approximately double that of trees on M I and more than double that of trees on Crab. Thus, planted at 20' x 20', these trees produced a yield of 1 ton 17 cwt. per acre. Obviously they could have been planted at 10' x 10' at which distance the yield would have been 7 tons 8 cwt. per acre, an outstanding yield for such young trees. It is estimated that these trees produced at least 2 tons per acre in 1941. Dabinett on M IX produced only a small yield per tree. At 20' x 20' the yield was only 15 cwt. per acre as against 2 tons for trees on Crab. At 10' x 10' this yield would be 3 tons per acre. The comparatively low yield of Dabinett on M IX is due to the very small size of the trees as compared with Dabinett on M I and Crab. It may be pointed out that Dabinett is a weak grower and that the mature trees, even on a strong stock, are small. A further point of interest is the fact that the highest yield of Dabinett is associated with the trees on Crab rootstock. This is probably due to the fact that these trees are larger and more vigorous than those on M I and that Dabinett is a particularly precocious variety.

The trees of Stoke Red on M IX also produced a small crop, 10 lb. per tree. Like Dabinett, these trees are small, so that before harvest the trees appeared to be cropping well. In fact some trees of Stoke Red on M IX did actually carry about 30 lb. of fruit, but as the majority of the trees carried very little, the average over the whole is reduced to 10 lb. per tree or 10 cwt. per acre. Even Type IX failed to induce Knotted Kernel to yield a measurable

crop, although the signs are that these trees will come into bearing in the near future.

(c) *Length of Leg.* The evidence shows no important difference in yield as between trees on the two different lengths of leg.

TABLE I.

SHOWING ESTIMATED YIELD PER ACRE OF BUSH CIDER APPLE TREES AT LONG ASHTON, ON THREE ROOTSTOCKS AND WITH TWO DIFFERENT LENGTHS OF LEG—110 TREES PER ACRE.

ESTIMATE BASED ON THE ACTUAL MEAN YIELD OF NOT LESS THAN 36 TREES.

Length of Leg.	M 1		Short. Crab		M IX		Long. M 1		Crab	
	Tons.	cwt.	Tons.	cwt.	Tons.	cwt.	Tons.	cwt.	Tons.	cwt.
Dabinett ..	1	10	2	0	—	15	1	5	1	17
Sweet Alford ..	—	15	—	10	1	17	—	13	9	
Stoke Red ..	Nil		Nil		—	10	Nil		Nil	
Knotted Kernel	Nil		Nil		Nil		Nil		Nil	
Kingston Black ..	1	0	—	12	—	18				

II. County Centres.

The yields at three county centres, viz. Compton Greenfield, Glos., Much Marcle, Hereford, and Poundisford, Somerset, are presented in Table II. At these centres there were good crops both in the plantations concerned and in the areas. Certain data are also available for Faversham, Kent, and Hereford (No. 1) centres, but as these are not individual tree yields, they can only be used in a general way. At the remaining centres, crops failed not only in the trial orchards but in the immediate neighbourhoods, suggesting that local conditions were responsible.

TABLE II.

SHOWING YIELDS PER ACRE OF BUSH CIDER APPLE TREES AT 3 COUNTY CENTRES. ESTIMATED FROM THE ACTUAL MEAN YIELDS OF FIVE TREES ON EACH ROOTSTOCK—110 TREES PER ACRE.

Centre. Rootstock.	Compton Greenfield, Glos.				Much Marcle, Hereford.				Poundisford, Som.			
	M 1		Crab		M 1		Crab		M 1		Crab	
	Tons.	cwt.	Tons.	cwt.	Tons.	cwt.	Tons.	cwt.	Tons.	cwt.	Tons.	cwt.
Broad Leaf Norman	7	—	5	14	1	16	1	14	1	17	1	0
Perthyre ..	3	—	2	10	1	11	1	1	2	8	1	0
Sweet Alford ..	Crop negligible				1	1	—	14	—	12	1	4
Dabinett ..	1	7	2	3	—	13	1	8	1	10	1	16
Chisel Jersey ..	2	8	2	17					2	14	2	14
Yarlington Mill ..	1	9	1	8					5	18	2	6
Reinette Obry ..					3	3	2	3				
White Jersey ..					4	3	4	2				
Reine de Pomme ..	1	6	1	0	2	0	2	0	1	16	1	15
Tardive Forestier ..									1	17	1	10
Ellis Bitters ..					2	3	2	8				
White Close Pippin ..					0	17	1	0				
Dove ..					1	5	1	11				
Medaille d' Or ..	1	18	1	11					1	4	1	3
Bulmers Norman	2	0	2	17	2	10	2	18		crop removed		

(a) *Variety*. Of the twelve varieties which occur at most of the county centres, Broad Leaf Norman, Perthyre, Chisel Jersey, Yarlington Mill and Bulmers Norman are outstanding as consistently high yielders. Several other varieties, notably White Jersey, White Close Pippin, Reinette Obry, Reine de Pomme and Ellis Bitters, while not present at every centre, have invariably given good yields. A number of other varieties, viz. Dabinett, Medaille d'Or, Sweet Alford and Tardive Forestier have also given good yields, but not up to the level of the first two groups. Knotted Kernel, Stoke Red and Slack-ma-Girdle have given no measurable crop as yet at any centre.

Of the five high yielding varieties Broad Leaf Norman and Yarlington Mill undoubtedly take pride of place. In Table II yields of 7 tons per acre for trees on M I and 5 tons 14 cwt. for trees of Broad Leaf Norman on Crab were given at Compton Greenfield. At Faversham (not shown in Table II) this variety had an average yield of over 200 lb. per tree or about 10 tons per acre. Yarlington Mill gave 5 tons 18 cwt. and 2 tons 6 cwt. for trees on M I and Crab respectively at Poundisford. The position of Perthyre may be mentioned at this point. Some growers maintain that the two varieties Broad Leaf Norman and Perthyre (Syn. Belle Norman) are identical, while others maintain that they are different. They were included in these trials partly because they are known to be vigorous and precocious and partly to allow a pomological study to be made with a view to settling this point. It is too early as yet to make any comments on this. Attention should be called to both Chisel Jersey and Bulmers Norman as consistently high yielders at all centres where they occur. In Table II they are shown to yield between 2 tons and 2 tons 18 cwt. per acre. At Faversham their yields are not less than 8 tons per acre. At Poundisford the yield was estimated at about 50—60 lb. per tree or 3 tons per acre, but the crop was removed before records were obtained.

Of the varieties which have given high yields but which are not widely distributed amongst the centres, White Jersey is outstanding. This is a local Hereford variety and was included at Much Marcle at the express wish of the grower. It gave a good crop last year and in 1942 gave an estimated yield of 2 tons per acre. From the pomological standpoint this variety shows great promise.

Reinette Obry has also cropped well, which was to be expected from experience with it as a standard tree in grass orchards. Ellis Bitters, a Devonshire variety, has also cropped satisfactorily. Reine de Pomme, a French variety brought to our notice by Messrs. Bulmers of Hereford, has also cropped well and shows promise. The variety Medaille d'Or deserves special note. This fruit has by far the highest tannin content of the whole range of varieties under trial, but is small. At most centres the crop was satisfactory. In fact at Faversham a full crop estimated at 80—90 lb. per tree was produced. Like Dabinett the tree lacks vigour and remains small. The small size of both the tree and its fruit militates against a high yield per acre. This is offset by the very high vintage quality of the fruits.

(b) *Rootstock*. There is so far no consistent effect of rootstock. In a few varieties, notable Dabinett and Bulmers Norman, the trees on Crab are more productive than those on M I, but on the whole the advantage is with the trees on M I. Outstanding cases of the effect of this rootstock is that of Medaille

d'Or and Royal Wilding at the Faversham centre. Here trees of these varieties on M I carried almost twice as much fruit as those on Crab. The characteristic effect of rootstock on growth is clearly visible.

(c) *Centre.* Management and soil conditions are major factors determining the productivity of the trees. At one centre, which was planted at the same time as all the others, records were abandoned after three years since the plot suffered a number of major disasters. The combined effect of soil, climate and culture is brought out by a comparison of the yields and tree size at Faversham with those at other centres. The total crop yield on this plot was 400 bushels or approximately 7 tons. This yield was obtained in spite of the fact that Rows 1, 2, 34, 35, were severely pilfered by hop pickers. The plantation foreman estimates that the best trees of Perthyre, Broad Leaf Norman, Sherrington Norman, Chisel Jersey, Yarlinton Mill and Bulmers Norman carried almost 2 cwt. of fruit per tree. A yield of nearly 4 tons per acre was actually achieved in this plantation in 1942, at six years from planting. The nearest approach to this is the Poundisford centre, where a nett yield of 2 tons per acre was obtained in spite of a considerable amount lost by pilfering. At the other centres the crop was about 30 cwt. per acre.

General Discussion.

Yields range from about 4 tons per acre at one centre to no crop at three others, with an average of about 30 cwt. per acre. There is no doubt whatever that with a better control of insect pests the yields could be improved. At two centres the crop was completely ruined by an infestation of caterpillars. At one of these the caterpillar damage was so severe that even at mid-summer the leaf was poor and weak, and it is unlikely that the trees will recover sufficiently to produce a strong blossom for 1943. At another centre the trees have been pruned rather severely each year and, while this has produced good trees, it has militated against their early cropping.

The trial has already yielded useful information upon varieties which are likely to grow and yield well as bush trees under a wide range of conditions.

THE CONTROL OF MANGANESE DEFICIENCY IN FRUIT TREES

By T. WALLACE and J. O. JONES.

During the season of 1942 experiments on the control of manganese deficiency in fruit trees were carried out at two centres to test the effectiveness of three possible methods of treatment, viz.: (1) Spraying the foliage with a solution of manganese sulphate early in the growing season; (2) injecting solid manganese sulphate into the main stem in March, just prior to bud break; (3) applying manganese sulphate and sulphur as fertilisers to the soil in March.

Of these three methods it was expected that (1) and (2) would prove satisfactory and that (3) might be ineffective.

The results have actually shown that the deficiency can be controlled by methods (1) and (2) and that of these method (1) (spraying) is likely to be very suitable for commercial practice.

CENTRE I.

Materials and Methods.

This centre is located on the Upper Greensand Formation in Wiltshire. The surface soil is a greyish black sand, well drained, with a high content of organic matter, pH of 7.2 and carbonate of lime content $> 10\%$.

Prior to its use for fruit growing the site had formed part of a dairy farm and had been heavily slagged. The fruits consist of apples and pears (dwarf pyramids planted at 6' by 3'), bush plums, black currants and blackberries. The main planting was carried out in 1935.

Of the above fruits, manganese deficiency symptoms are prevalent in apples, pears and plums, but only very slight visible effects can be seen in black currants and the blackberries appear to be unaffected.

The trees were first examined on 25/8/41 when certain areas of apples were marked down as being severely affected and a number of plum trees were also selected as requiring treatment. On this occasion it was also noted that potatoes growing in one part of the plantations were showing signs of manganese deficiency.

On 2/9/41, a small area of apple trees was selected for an experiment in 1942 and the trees were classified according to the degree of severity of manganese deficiency symptoms. Eight trees in this area, four showing severe chlorosis and four a medium amount, and one severely chlorotic plum were sprayed with manganese sulphate solution at 1% strength on this date to see whether any improvement could be effected by late spraying and to determine the likelihood of foliage damage. Some damage resulted and no effect on the deficiency symptoms could be observed from the spray treatment during the remainder of the season. The plum tree was also kept under observation during 1942 and no effects of the spraying could be discerned.

The following experiments were carried out in 1942 :—

Stem Injections.

26/3/42.

Apples. Nine dwarf pyramid apples, variety Early Victoria, all severely chlorotic in 1941, were injected in the trunks with manganese sulphate, using the method of Bennett(1) and dosages at the same rates as recommended by him for iron injections.

Plums. Three bush trees, variety Giant Prune, were injected, using the same technique as for the apples.

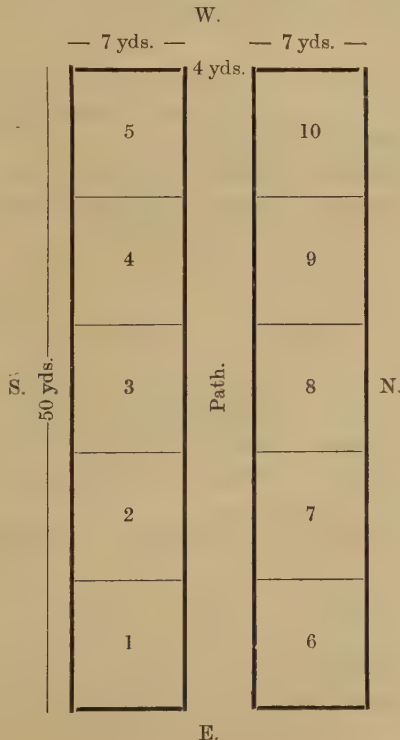
21/5/42.

Apples. Four dwarf pyramid apples similar in all respects to those treated on 26/3/42 were injected in the trunks with iron citrate, using Bennett's method, to see whether iron deficiency contributed in any part to the chlorotic condition.

Spraying and Fertiliser Treatments.

Apples. Two blocks of dwarf pyramid apple trees, each measuring 50 yards by 7 yards and separated along their length by a path 12 ft. wide, were utilised for the main experiment. Each block contained three rows of trees and was divided into five plots, each measuring 10 yards by 7 yards.

The arrangement and method of numbering of the plots is shown in the following diagram :—



The following treatments were given :—

Fertilisers : applied 26/3/42.

Plot 2. Ground sulphur at 1 ton per acre = 32 lb. to the plot.

Plot 3. Manganese sulphate at 100 lb. per acre = $1\frac{1}{2}$ lb. to the plot.

Plot 4. Sulphur plus manganese sulphate at rates given to plots 2 and 3.

Spray Treatments : applied as petal fall spray 21/5/42.

Plot 1. Water.

Plot 5. Manganese sulphate 3 lb. per 100 gall. water.

Plot 6. " " 5 lb., hydrated lime 2.5 lb. per 100 gall water

Plot 7. " " 3 lb., " " 1.5 lb. " " "

Plot 8. Ferrous sulphate, 3 lb. per 100 gall. water.

Plot 9. Manganese sulphate 3 lb., soda ash 1.5 lb. per 100 gall. water.

Plot 10. " " 3 lb., lime sulphur 1 gall. " "

The following spray treatments were also given to groups of apple trees in the two rows adjoining plots 6 to 10, the groups being designated as plots 11 to 14.

21/5/42.

Plot 11. Manganese sulphate 3 lb., ferrous sulphate $2\frac{1}{2}$ lb. per 100 gall. water.

15/6/42.

Plot 12. Manganese sulphate 5 lb., hydrated lime 4 lb. per 100 gall. water.

Plot 13. Manganese sulphate 5 lb., copper sulphate 2 lb., hydrated lime 4 lb. per 100 gall. water.

Plot 14. Copper sulphate 2 lb., hydrated lime 4 lb. per 100 gall. water.

In applying all sprays a small knapsack sprayer was used and the foliage was thoroughly wetted.

A row of globe beetroot was sown in one of the alleyways throughout plots 1 to 5 to observe the effects of the fertiliser treatments on this crop which is highly susceptible to manganese deficiency.

Results.

The results of the treatments were recorded on two occasions, 26/6/42 and 21/9/42.

In recording the results on the spraying and fertiliser plots on the first date each plot was given a mark, ranging from 10 to 0, 10 indicating all trees as being perfectly green and 0 all trees as severely chlorotic ; on the second date each tree was marked according to the degree of chlorosis present on the following basis :—

Trace = $\frac{1}{4}$; Very Slight = $\frac{1}{2}$; Slight = 1 ; Medium = 2 ; Severe = 3.

26/6/42.

(a) *Injection Treatments.*

(i) *Manganese Sulphate.*

Apples : Of 9 treated trees : 7 green ; 1 chlorosis very slight ; 1 chlorosis trace.

Plums: 3 injected trees: 2 green; 1 chlorosis trace; 3 controls: 2 chlorosis medium; 1 chlorosis medium to severe.

(ii) *Iron Citrate*.

Apples: Of 4 treated trees: 4 chlorosis severe.

(b) *Fertiliser and Spraying Treatments*.

Sprayed 21/5/42: Plot 1—7; Plot 2—5; Plot 3—4; Plot 4—3; Plot 5—9; Plot 6—8½; Plot 7—9½; Plot 8—6; Plot 9—9; Plot 10—10; Plot 11—9.

Sprayed 15/6/42: Plot 12—7; Plot 13—6; Plot 14—5.

In the injection experiment it was clearly evident that manganese sulphate had effected a cure of the chlorotic condition and that iron citrate treatment had been without effect. No damage resulted from any of the injections, though there was slight gumming in the case of the plums.

The results from the fertiliser and the 21/5/42 treatments indicated that all the manganese sulphate spraying treatments were effective whereas the iron sulphate spray and both fertiliser treatments were ineffective. It should be noted that the 1941 chlorosis markings showed that trees on plot 1 were less severely affected than on the other plots, hence the selection of this plot for the water treatment. No foliage damage was caused by any of the manganese sulphate spray treatments but there was slight damage from the iron spray.

This date was considered rather early for results to have followed from the 15/6/42 spray treatments but it did seem that slight beneficial effects were evident on plots 12 and 13 where manganese sulphate had been included.

21/9/42.

(a) *Injection Treatments*.

The results from these were substantially as recorded as 26/6/42, the manganese sulphate treatment being entirely effective and the iron citrate treatment without observable effect.

(b) *Fertiliser and Spraying Treatments*.

The results of the detailed records of the individual apple trees are summarised in the following table. Slight foliage damage and russetting of the fruits was evident from the iron and copper sprays.

EFFECTS OF FERTILISER AND SPRAYING TREATMENTS ON THE INCIDENCE OF CHLOROSIS.

Plot No.	Treatment	No. of Trees on Plot.	No. of Trees showing Chlorosis.	Average marking per tree for Chlorosis.
	<i>Sprays applied 21/5/42 :—</i>			
1	Spray—Water	26	26	0.74*
2	Fertiliser—Sulphur	29	28	1.41
3	Fertiliser—Manganese sulphate	28	28	1.87
4	Fertiliser—Sulphur plus manganese sulphate	25	25	1.83
5	Spray—Manganese sulphate 3 lb.	22	1	0.01
6	Spray—Manganese sulphate 5 lb.; hydrated lime 2.5 lb.	25	1	0.01

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Plot No.	Treatment.	No. of Trees on Plot.	No. of Trees showing Chlorosis.	Average marking per tree for Chlorosis.
7	Spray—Manganese sulphate 3 lb. ; hydrated lime 1.5 lb.	27	4	0.04
8	Spray—Ferrous sulphate 3 lb.	23	21	1.25
9	Spray—Manganese sulphate 3 lb. ; soda ash 1.5 lb.	28	1	0.01
10	Spray—Manganese sulphate 3 lb. ; lime sulphur 1 gall.	25	0	0.00
11	Spray—Manganese sulphate 3 lb. ; ferrous sulphate 2½ lb.	Not recorded		
Sprays applied 15/6/42 :—				
12	Spray—Manganese sulphate 5 lb. ; hydrated lime 4 lb.	18	14	0.47
13	Spray—Manganese sulphate 5 lb. ; copper sulphate 2 lb. ; hydrated lime 4 lb.	28	24	0.65
14	Spray—Copper sulphate 2 lb. ; hydrated lime 4 lb.	17	14	1.15

* Trace = 0.25 ; Very slight = 0.50 ; Slight = 1.0 ; Medium = 2.0 ; Severe = 3.0.

The results show clearly the effectiveness of the 21/5/42 (petal fall) spray treatment with manganese sulphate. Those for the later spraying though effecting considerable improvement were not so good, which points to the necessity of an early application. The combination of manganese sulphate with lime sulphur on plot 10 is of special interest as it shows that manganese sulphate can be incorporated in the usual petal fall lime sulphur spray thus obviating a special application for apples.

The iron and copper sprays produced no observable improvements and the results with the former were confirmed by the injection treatment.

Manganese sulphate and sulphur applied as fertilisers appeared to be entirely without effect on the trees although sulphur treatment produced a marked result on the interplanted globe beet.

CENTRE II.

This experiment was carried out on apple trees on one of the fruit plots at the Cannington Farm Institute, Somerset. The soil is a medium to heavy fine sandy, silty loam derived from parent materials of Devonian and Keuper origin. The site, although on a slope, is somewhat wet. The soil has been under apples with clean cultivation treatment and occasional cover crops for several years. The surface soil contains from 2% to 3% of carbonate of lime and has a pH 7.0.

Materials and Methods.

The trees used in the experiment are either bush or half standard apple trees, approaching 20 years old, and have grown fairly well. Symptoms of manganese deficiency have only been noted for two or three seasons.

On 5/9/41 a number of trees were recorded for manganese deficiency symptoms and eight of them were selected for injection treatment with manganese sulphate in 1942. The remainder were to be left untreated as controls and were comparable as regards severity of manganese symptoms with those selected for treatment.

The manganese sulphate injections were made on 17/3/42, using the method of Bennett and the dosages given by him for iron treatment.

Results.

The results of the treatments were recorded on 30/7/42 and will be evident from the following table.

RESULTS FOR INJECTED TREES.

Tree No.	Variety.	Chlorosis 5/9/41.	Chlorosis 30/7/42.
Row 8, Tree 1	Unknown	Very slight	Nil
" 5, " 8	Charles Ross	Medium	Slight one branch
" 5, " 12	" "	Very slight	Nil
" 5, " 13	Ellison's Orange	Slight	Nil
" 5, " 14	Blenheim Orange	Very slight	Nil
" 6, " 2	Charles Ross	Slight	Nil
" 6, " 12	" "	Medium	Trace one branch
" 14, " 14	" "	Very slight	Nil

In contrast to the injected trees the comparable controls all showed medium chlorosis on 30/7/42.

Summary.

1. Experiments on the control of chlorosis of fruit trees, due to a deficiency of manganese, were carried out at two centres in 1942.

2. The treatments tested were as follows: solid injections with manganese sulphate and ferric citrate, using the method of Bennett, on apples and plums; spraying with manganese sulphate, ferrous sulphate and copper sulphate at petal fall stage and later, on apples; application of manganese sulphate and sulphur separately and together as fertilisers in March, on apples.

3. The injection and spraying treatments with manganese sulphate were effective in controlling the chlorosis, but the application of manganese sulphate and sulphur as fertilisers were without effect, although sulphur treatment controlled manganese deficiency in globe beet growing between the trees on the fertiliser plots. The copper and iron treatments produced no beneficial effects.

4. The results suggest that a commercial control of manganese deficiency in apple trees will be readily obtained by the addition of manganese sulphate at a rate of 3 lb. per 100 gall. to the usual petal fall lime sulphur spray. Spraying at a later stage is likely to give poorer results.

Acknowledgments.

Thanks are due to Messrs. E. W. Hobbis and L. Ogilvie for assisting at the Wiltshire centre and to Messrs. A. D. Turner, J. E. Forshaw and Miss C. Clarke for their help at Cannington.

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THE EFFECT OF NAPHTHALENE-ACETIC ACID AND NAPHTH-OXY-ACETIC ACID ON FRUIT SET AND DEVELOPMENT OF TOMATO AND STRAWBERRY PLANTS.

PROGRESS REPORT

By T. SWARBRICK.

Introduction.

It is well known that the strawberry variety Tardive de Leopold is self-sterile and that Oberschlesien is partially so. Both varieties require adequate cross-pollination in order to produce satisfactory crops. Even when pollinator plants are provided, it frequently happens that the latter half of the flowers are not pollinated and only half a crop results.

In tomatoes it is also well known that certain varieties do not "set" so freely as others and that under certain conditions fruit setting is not satisfactory. This is particularly true of "cold" house-grown tomatoes.

Since 1939 there has been a remarkable development in the application of certain chemicals to the growth of plants. Some chemicals quicken and others retard certain phases of growth. It is well known, for example, that naphthalene-acetic acid will encourage the rooting of certain plant material. This same substance also delays the abscission of leaves and fruits. New substances are being synthesised and the choice of chemicals is now considerable, although in the main there are but few that are sufficiently cheap and active to allow of their use in commercial horticulture.

In 1940 the workers at the Boyce Thompson Institute published the results of their work on a new chemical which they had themselves synthesised. This was a substitution product of the well known naphthalene-acetic acid and was named naphthoxy-acetic acid. For convenience and ease of reference this new compound is called N-O-A. It was found that N-O-A stimulated the growth of plant reproductive tissues, so that when sprayed into unopened flowers it caused the development of seedless fruits. Success was reported with tomatoes in particular.

Since N-O-A is comparatively easy to produce and reasonably cheap, it provides a possible means of facilitating a better fruit "set" in the two strawberry varieties Tardive and Oberschlesien. A small preliminary trial with this object was carried out in 1942.

Material and Methods.

A supply of N-O-A was produced at Long Ashton by Dr. Wain from directions supplied by the Boyce Thompson Institute. Preliminary trials proved it to be of high physiological activity. A stock solution in alcohol was made up according to the directions. Trials on tomatoes were made in the greenhouse at Long Ashton and on strawberries growing under commercial conditions on a fruit farm at Ross-on-Wye, Hereford. In order to provide a standard of comparison the trials included naphthalene-acetic acid used at

the same concentration, although there was no evidence to suggest that this substance had any influence either way on fruit set. The trial on strawberries also included the use of a wetting agent, in this case "Ester Salts" which are obtained as a by-product in petroleum refinement.

Results.

Tomatoes.

The variety used was Plumpton King growing in ten-inch pots alongside a wall in a heated greenhouse. In 1941 great difficulty was experienced with this variety in this house. The plants grew well but failed to "set," whereas other varieties were normal in every way.

The sprays were applied at a dilution of 0.001% (ten parts of chemical in one million parts of water) by means of a small hand-operated atomiser. Applications were made over a period of about a month and at various stages of plant development. In all cases care was taken to direct the spray on to the flower truss. It was of course impossible to prevent some spray falling on to the main stem, and to some extent on to the leaves, but this was kept to a minimum.

The results, so far as fruit development was concerned, were most disappointing, since without exception plants sprayed with N-O-A and, to a less extent, naphthalene-acetic acid suffered a severe check to their growth and development.

Spray application was followed within 12-14 hours by marked epinasty of the parts where the spray touched. But within a week or ten days from spraying the general growth of the plant began to fall behind that of control plants. Although the sprayed flower trusses continued to develop for some weeks they made unsatisfactory growth. The spraying of a single flower truss, say the third from the base, resulted in a stunted yellow plant which produced small fruits, many of which did not ripen properly, particularly on the plants sprayed with naphthalene-acetic acid.

The cause of this very marked effect upon the general growth and vigour of the tomato plants is not at present clearly understood. It is recognised that naphthalene-acetic acid retards leaf fall and fruit development, but in this case the plants looked sickly and unhealthy. It is possible that this result may be due either to the high alcohol content of the spray fluid used, or to a high concentration of growth substance. These points will be investigated during 1943.

In spite of the unexpected result, it is clear that both naphthalene-acetic acid and N-O-A affect the growth and development of the tomato plant. Further work is needed to be able to utilize these effects in advantageous directions. In any case, the effect of naphthalene-acetic acid in retarding fruit development is further substantiated.

Strawberries.

For this part of the trial a field of strawberries was selected on a fruit farm where it was known that good plants were being grown. These flowered profusely but the yield was not satisfactory owing to the latter part of the crop failing to develop.

The variety Tardive de Leopold was planted in blocks of eight rows

wide alongside blocks of Royal Sovereign, also eight rows wide. Both varieties were three years old and making satisfactory growth.

The sprays were applied on June 9th, 1942, by which date the Sovereign plants had finished flowering and had set an excellent crop of fruit. The Tardive plants were in full flower, with the later blossoms still unopened. Careful examination showed that the early flowers of the Tardive plants had been pollinated and were "setting" satisfactorily. As there were no more Sovereign blossoms it was clearly impossible for the rest of the Tardive flowers to be pollinated. Sprays applied at this date were, therefore, calculated to have an effect upon the second half of the crop.

Two blocks of four rows wide were selected in the two best parts of the field. These blocks were buffered on both sides by two rows of plants of the same variety. The sprays were applied by a large hand-operated knapsack sprayer. Two litres of each spray were used. The plants were well covered at the expense of a little waste of wash so that there would be no doubt as to the effectiveness of the cover. The weather at the time of application was warm and dry. No rain fell for over 48 hours after spraying.

The following solutions were used :—

1. Control. Distilled water only.
2. N-O-A. 500 mg./litre in distilled water.
3. N-O-A. 500 mg./litre in distilled water plus 1 c.c. of a 20% solution of Ester Salts per litre of solution.
4. Naphthalene-acetic acid. 500 mg./litre in distilled water.
5. Naphthalene-acetic acid. 500 mg./litre in distilled water plus 1 c.c. 20% solution of Ester Salts per litre of solution.

Owing to war-time conditions it was found impossible to obtain crop weights from these plots. The plantation manager very kindly collected observations at intervals. The following are extracts from two of his reports.

Report dated 18/6/42 :—

" . . . The only effect I have been able to see so far is that rows 31, 32, 47 and 52 showed a considerable drooping of the leaves almost at once after you had sprayed. The leaves have to some extent recovered but the petioles have in many cases remained bent."

The four rows referred to were those sprayed with naphthalene-acetic acid (treatments 4 and 5).

Report dated 26/6/42 :—

" I have been keeping as good a watch on your sprayed Tardives as time has allowed and don't particularly like the look of some of the rows. Those I mentioned in my last letter now show the effect more severely and it appears to have delayed the growth of the berries considerably and to have delayed ripening. So far no fruit has been picked from these rows although we have twice picked over the rest of the patch."

It should be noted that the manager picked out the rows treated with naphthalene-acetic acid and reported exactly the same effects as this substance is known to exert on other plants. In order to prevent any unconscious bias the plantation manager was not given a key to the treatments. He was not even told what to look for but to report what he found. A

detailed examination was made on July 6th, 1942, when the following points were noted.

Naphthalene-acetic acid. The plants sprayed with this substance showed marked twisting and distortion of the petioles, so much so that the crowns of the plants were exposed. The effect was confined to the petioles. The flower stalks appeared normal.

The second point noted was the delayed development and ripening of the fruit. By this date the remainder of the Tardive plants had been picked three times and another picking was due on the following day, but there were still no ripe fruits on the plants sprayed with naphthalene-acetic acid. It was estimated that the first pick from these plants would not be ripe until July 10th-12th, that is ripening had been delayed for over 21 days.

There was no apparent effect on fruit set; the first half of the flowers had set fairly well but the second half had failed to do so.

No difference due to the use of a spreader could be seen.

Naphthoxy-acetic acid. There was no doubt about the effect of N-O-A on fruit set. At this time (July 6th, 1942) the picking season was about half over and the plantation manager was certain that there had been no difference in yield as between the N-O-A sprayed and the unsprayed portions. On July 6th, however, the plants sprayed with N-O-A were still carrying a very heavy crop of fruit. Many of the later-formed flowers—flowers which opened after the Sovereign plants had finished flowering—were developing normally into perfectly shaped fruits. A further examination showed that many of these fruits, although practically perfect in shape, did not possess a full complement of achenes. Each one had some seeds but they were often sparsely distributed. The N-O-A had apparently encouraged the development of the fruits despite the fact that there was a very meagre "set" of seeds. It was estimated that the sprayed plants would produce at least one-third again as much fruit as the unsprayed plants.

As in the case of naphthalene-acetic acid there was no apparent difference due to the use of a spreader.

General Conclusions.

This preliminary trial has shown that at a concentration of 0.001% (ten parts per million) naphthalene-acetic acid delays fruit development in both tomato and strawberry. This is accompanied by marked twisting (epinasty) of the petioles. The ripening of strawberry fruits was delayed by 21 days as the result of one spray application put on at full flower.

N-O-A (naphthoxy-acetic acid) markedly improved fruit "set" and development in Tardive de Leopold strawberry. The increase in commercial crop was estimated at not less than one-third that of the unsprayed plants. Many of these fruits were normal in shape notwithstanding the fact that they did not have the full number of seeds. There is much less epinasty associated with this compound than with naphthalene-acetic acid.

The use of a spreader had no influence upon the effectiveness or otherwise of the two compounds.

The possible uses of these two compounds are considerable. In the case of the two strawberry varieties Tardive de Leopold and Oberschlesien it should be possible to combine the effects of both substances. In this way one should be able to obtain a delayed ripening and so spread the picking and marketing season, along with an increase of the fruit crop. On the results of this one trial it was estimated that the increase in yield due to the use of N-O-A was at least one ton of fruit per acre. It is hoped to extend the work in 1943 and to carry out more carefully controlled pollination tests on strawberry plants in pots under greenhouse conditions at Long Ashton.

THE INFLUENCE OF CERTAIN SPRAYS ON THE PRE-HARVEST DROP OF APPLES.

PROGRESS REPORT II.

By T. SWARBRICK.

A progress report, issued in the Annual Report for 1941, showed that with the apple variety King Edward VII, naphthalene acetic acid at 10 parts per million (.001%) reduced the pre-harvest fruit drop by 15%. This result was obtained under unusually severe weather conditions, which included a 40—50 miles per hour gale. While a nett gain of 15% is not sufficient to warrant the use of such sprays under ordinary commercial conditions, the results justified further investigations along similar lines. The present report deals with results obtained during 1942 and includes the use of a new substance naphthoxy-acetic acid. In these trials both naphthalene acetic acid and naphthoxy-acetic acid have reduced the pre-harvest drop of apples in the variety Allington Pippin but not in the variety King Edward VII.

Materials and Methods.

In 1942 both Allington Pippin and King Edward VII were available. Both varieties were carrying good crops. Sixty trees of each variety were available, twenty trees for each of three separate treatments, including the controls. The twenty trees in each treatment were divided into four replicates giving a maximum of five trees of each variety per replicate.

Since no further beneficial influence was obtained in 1941 by increasing the concentration of naphthalene acetic acid above .001%, this strength was adopted in the 1942 trials. Naphthalene acetic acid was again the main substance under trial, but naphthoxy-acetic acid was included for preliminary test. This latter substance, known under its initial letters N-O-A, has been introduced and developed mainly in connection with the problems of "fruit-setting." A short account of its effects in this connection is given elsewhere in this report. Its influence on the pre-harvest drop of apples was unknown, but it was given a trial, as it is a substitution product of naphthalene acetic acid. The material was prepared at Long Ashton by Dr. Wain from directions supplied by The Boyce Thompson Institute, U.S.A.

For application to the trees the chemicals were first of all dissolved in a small quantity of ethyl alcohol, as they are insoluble in water. This alcoholic solution was then added slowly to the required volume of water, the latter being stirred during the operation. Five gallons of spray were allowed per tree, an amount sufficient to provide a good cover. The spray was applied at a pressure of 400 lb. per square inch on 1st October, 1942, by which date a small number of fruits were dropping. Under normal seasonal conditions October 1st would be regarded as very late, but the 1942 fruit picking season was on the average about 14 days later than usual. As will be pointed out later the timing of the spray application is a matter of considerable importance and requires further investigation, but the above date was chosen from previous

experience as being most likely to provide the maximum effect possible from a single application.

All fruit drops were picked up, counted and weighed on September 30th immediately prior to the spray application. The fruits which fell subsequent to spraying but prior to harvesting the crop were picked up, counted and weighed on October 19th and again on October 26th, the latter date being immediately prior to picking. Harvesting began on October 27th and was completed on November 4th, so that a period of from 27 to 32 days elapsed between spraying and harvesting the various trees. In this connection it is usually recognised that the period between spraying and harvesting should not exceed three weeks. Two factors were responsible for the delay. Firstly the trees are part of a pruning and shaping experiment and in view of this it is essential to adopt special measures in picking over the whole plot; secondly in 1942 "quality" in the fruit was slow in developing due to frequent cold wet periods.

Results.

The results are set out in Table I which shows that, while there was no effect on the variety Edward VII, both treatments reduced the pre-harvest drop in Allington by amounts significant at odds of twenty to one. Naphthalene acetic acid proved to be more effective than the new substance naphthoxy-acetic acid.

TABLE I.

SHOWING MEAN % DROP OF FRUIT IN THE TWO VARIETIES ALLINGTON PIPPIN AND EDWARD VII.

				Mean % Drop.	P.E.M.	Sig. Difference.
Allington.	Control	..	..	16	1.23	
	Treatment 1	..	..	11	1.28	+
	Treatment 2	..	..	8	0.86	+
Edward VII.	Control	..	..	9	—	
	Treatment 1	..	..	9	—	Nil
	Treatment 2	..	..	9	—	Nil

The data obtained in 1942 brought out one important point, namely, the wide variation in fruit drop from tree to tree in both the controls and the trees under treatment. This point calls for further investigation. At present no reason can be given for this wide variation. It does not show any positive correlation with the 1942 crop, *i.e.* high and low percentage pre-harvest drop occurs on trees with both high and low yields. It is possible, of course, that there is a correlation with the 1941 crop, but time and opportunity have not allowed this point to be examined. Clearly there is some factor which predisposes individual trees towards a high or a low percentage pre-harvest drop. A spray application which can show a significant result notwithstanding this must be really effective.

A second point to note is the fact that no significant result was obtained with King Edward VII in 1942, although the variety responded in 1941. The reason for this negative result in 1942 is not clear. It cannot be general conditions, since a positive result was obtained with Allington Pippin. One suggestion is that although the effect of these substances is supposed to be transitory, these Edward trees have now been sprayed two years in succession and a residual effect may be produced.

In conclusion the 1942 trials, although on a larger scale than those of 1941, (Ann. Rept. 1941, p. 19), do not provide a basis for practical recommendations to commercial fruit growers. They have, however, served to emphasise the complexity of the problem and the many factors which require detailed investigation.

The writer would be glad to hear from growers in the West Midlands fruit areas who have experienced unduly large pre-harvest drops in past seasons, with a view to arranging small-scale spraying trials. Owing to present difficulties of supply it will be necessary to make arrangements well in advance.

MANURIAL EXPERIMENTS ON VEGETABLE CROPS.

III. EFFECTS OF FARMYARD MANURE AND OF VARIOUS FERTILISER TREATMENTS ON ONIONS.

By T. WALLACE, H. E. CROXALL AND P. T. H. PICKFORD,

The results reported in this paper are for onions, as the third crop of the series of which the two previous crops were savoys and carrots (1). The layout of the plots and the scheme of manurial treatments are described in the previous paper. For the onion crop two adjustments were made in the general manurial scheme, *viz.* farmyard manure was applied at 10 tons per acre *vice* 5 tons for the previous crops and the nitrogen dressing was at the rate of 3 cwt. of nitro chalk per acre. The farmyard manure dressing was increased as experience with the previous crops had indicated that the 5 ton rate dressing was too low. The general scheme allows for the adjustment of the nitrogen dressing for each particular crop.

Two varieties of onion—Bedford Champion and Red Wethersfield—were used owing to difficulties in obtaining sufficient seed of a suitable variety. The varieties were sown in alternate rows on all plots, the distance between rows being 1 foot and the rate of seeding 3 lb. per acre.

A first sowing was made on March 27th, but this failed, and both varieties were re-sown on April 25th. Germination from the second sowing was also poor, Bedford Champion again being practically a failure, and for this reason it was omitted from further records.

Results.

Visual markings on Red Wethersfield for germination and growth were made on July 29th and a further growth marking was recorded on September 4th. The results are given in Table I.

TABLE I.
GERMINATION AND GROWTH RECORDS.

Date and Nature of Observation.	Manurial Treatments.							
	Nitrogen only.	Farmyard Manure.	Complete Fertiliser (N.P.K.) with Sulphate of Potash.	Nitrogen Omitted.	Phosphate Omitted.	Potash Omitted.	Nitrogen Phosphate and Muriate of Potash (N.P.K.).	Nitrogen Phosphate and Salt (N.P. Salt).
29/7/42 Germination	3	4	4	3	4	2½	3½	3½
Growth	½	3½	2½	½	2½	1½	3½	4½
4/9/42 Growth	4	6	5½	3	6	3½	8½	7½

In all three markings the possible number of marks for each entry was 12.

It will be seen from the records for 29/7/42 that germination was similar for all treatments and was of a low order, being from $\frac{1}{3}$ to $\frac{1}{4}$ of a full commercial plant. Growth was extremely weak at the July recording, but by September 4th, just prior to harvesting, it had improved considerably although it was still unsatisfactory for all treatments.

The crop was harvested on 8/9/42 and the bulbs graded into "good" and "thick necked." The relevant data are given in Table II.

TABLE II.
CROP WEIGHTS OF TOTAL AND "GOOD" ONIONS (TONS PER ACRE).

	Phosphate Omitted.	Farmyard Manure	Complete Fertiliser with K_2SO_4 .	Nitrogen only.	Potash Omitted.	Nitrogen Omitted.	Complete Fertiliser with KCl.	Nitrogen Phosphate and Salt.
Total	4.35	3.7	3.04	2.45	2.17	1.66	5.50	5.25
Significant differences: 5% point 1.5 tons; 1% point 2.1 tons.								
Good	2.21	2.36	1.88	0.80	1.16	0.98	3.53	3.38
Significant difference: 5% point 1.7 tons.								
% Good in Total ..	50.7	63.2	61.6	32.7	53.5	59.1	64.1	64.5

The total yields shown for all treatments were very low, and in explanation of this fact it should be pointed out that Red Wethersfield only occupied one-half of each plot, the rows of this variety being 2' apart, germination was only from $\frac{1}{3}$ to $\frac{1}{4}$ of a full commercial plant and growth was only poor. The poor growth may have been largely due to two causes: late sowing following an initial failure; the fact that the onions followed a very heavy crop of carrots of which the yields for all plots were over 30 tons per acre.

As to the actual order of yields, phosphate omitted and farmyard manure were the only treatments to show significant increases in yields over other treatments, the former over three others and the latter over one only, nitrogen omitted.

The yields for the plots receiving muriate of potash and salt were not included in the statistical analysis, as the plots are located outside the main block of plots. It should be noted, however, that the yields are higher than for any other of the treatments which suggests that chloride-containing fertilisers do not injure onions.

The only point of note with regard to the data for good onions was the very low percentage of good onions on the nitrogen only plots.

REFERENCE.

- (1) WALLACE, T., CROXALL, H. E., and PICKFORD, P. T. H. Manurial Experiments on Vegetable Crops. I. Effects of Farmyard Manure and of various Fertiliser Treatments on Savoys and Carrots. *Ann. Rept. Agric. and Hort. Res. Stn., Long Ashton*, p. 25, 1941.

MANURIAL EXPERIMENTS ON VEGETABLE CROPS.

IV.—EFFECTS OF FARMYARD MANURE AND OTHER MANURIAL TREATMENTS ON SPRING CABBAGE AND CARROT CROPS.

By T. WALLACE, H. E. CROXALL and P. T. H. PICKFORD.

The crops discussed in the present paper followed in succession on the savoy and early potato crops reported on in Part II of this series of papers (1).

The following adjustments in the manurial treatments as listed for savoy in the previous paper were made for the two crops :—

Spring Cabbage: Nitro chalk rate, as the standard dressing for nitrogen, was at 8 cwt. per acre *vice* 6 cwt. ; half was applied at planting and half as a top dressing in spring. As only 35 lb. per plot of town refuse was available *vice* 3½ cwt. required, this material was applied to Plots G, but in addition a dressing of nitro chalk, at the rate of 8 cwt. per acre, was given. Plots D, which should receive hoof to supply twice as much nitrogen as in the nitro chalk applied to Plots E, received hoof at 8 cwt. per acre at planting, and nitro chalk at 4 cwt. per acre as a top dressing in spring. The basal dressing in Plots D thus contributed twice the nitrogen in the form of hoof as the basal dressing of nitro chalk in Plots E, but both sets of plots received identical top dressings of nitro chalk.

Carrots: Nitro chalk rate was at 3 cwt. per acre. Hoof in Plots D was at twice the nitrogen rate of nitro chalk. Plots G received an experimental compost, consisting of a sludged town refuse, applied at a rate calculated to supply twice the nitrogen given in the nitro chalk dressing.

A. SPRING CABBAGE.

The basal manures were all applied on September 10th, 1941, and the top dressings given on March 14th, 1942. Planting was carried out during the period September 15th—17th. The variety was Clucas 218. Owing to the very dry conditions at the planting time, the planting operations were postponed about a fortnight after the plants had reached their optimum planting stage in the seed bed and this resulted in the plants being somewhat "leggy."

Weather Conditions. Weather conditions throughout the experiment were very unfavourable for the crop. September was very dry and the plants only survived with difficulty. During October to December inclusive, conditions were generally mild and wet and more favourable to growth. In January and February there was much frost and snow and vegetable crops throughout the country suffered severely. During March, April and early May, whilst the cabbage crop still occupied the plots, growing conditions remained notably unfavourable, with low temperatures prevailing and frequent frosts. As a result of the conditions in early 1942 the plants suffered severe damage and never properly recovered.

Results.

Observations on Growth. The plants were well established and making healthy growth on all plots on October 22nd, and by the end of December growth was "forward."

Following the severe weather conditions of January and February vigour markings were given on three occasions—March 14th, April 18th, and May 7th, the last date being only a few days prior to cutting for market.

The points awarded for the various treatments were as follows :—

TABLE I.
SPRING CABBAGE—GROWTH MARKINGS.

Date.	A.	B.	C.	D.	E.	F.	G.	H.
March 14th ..	8 $\frac{1}{4}$	9 $\frac{1}{4}$	7 $\frac{3}{4}$	8	9	6 $\frac{3}{4}$	8 $\frac{1}{4}$	7 $\frac{3}{4}$
April 18th ..	5 $\frac{1}{4}$	7 $\frac{1}{2}$	8	8 $\frac{3}{4}$	7 $\frac{3}{4}$	7 $\frac{3}{4}$	8 $\frac{1}{4}$	6 $\frac{3}{4}$
May 7th ..	5 $\frac{3}{4}$	8 $\frac{1}{2}$	9	10	9 $\frac{1}{2}$	9 $\frac{1}{4}$	10	9

The total possible points for each treatment on each occasion was 12, so that it will be seen that on March 14th the condition of the plants on all plots was only moderate or poor. On this date top dressings of nitrogen were given according to the scheme, the only plots not receiving nitrogen at that time being Plots A, the farmyard manure plots. The effect of the top dressings is clearly seen in the improvement of all plots excepting A by May 7th and the deterioration in condition of the plants on Plots A.

On March 14th the plants on all plots showed severe purpling and killing of tissue, and even by May 7th there was still much purpling and only comparatively little "hearfing."

Crop Weights. The whole crop was cut on May 12th and 13th. The data for yields, as tons per acre, were as follows :—

TABLE II.
SPRING CABBAGE—CROP WEIGHTS.

	A.	B.	C.	D.	E.	F.	G.	H.
Tons per acre ..	3.61	4.68	4.77	5.47	5.27	5.33	5.93	4.81
Order of Yields ..	8	7	6	2	4	3	1	5

Significant differences : at 5% point 0.75 tons ; at 1% point 1.04 tons.

The outstanding point in the results is the effect of the spring top dressing of nitrogen, Plots A, which had no top dressings, giving yields significantly lower than all other plots at the 1% point. Plots B and C, which received top dressings at half the rates of the other plots gave the next lowest yields, and these were significantly lower than those on Plots G at the 1% point.

Plots D, receiving the basal dressing of hoof and the spring dressing of

nitro chalk, was second in order of yield to G, which had a full dressing of inorganic nitrogen plus a small dressing of town refuse. The result for Plots G is of interest in that for a previous savoy crop when a full dressing of town refuse but no inorganic nitrogen was given the yield was the lowest of all treatments.

The outstanding practical point which has thus emerged both from this experiment on spring cabbage and from the previous one on savoys is the predominant need of such crops for nitrogen. For spring cabbage the importance of the spring dressing is also indicated.

B. CARROTS.

The manurial dressings were all applied on May 20th, 1942. The variety used was Blatchford's Stump Rooted and the seed was sown on June 3rd at the rate of 3 lb. per acre. Growth conditions throughout the experiment, especially during the later stages, were generally favourable and very heavy crops were harvested.

Results.

Observations on Growth. Markings were made on July 29th for germination and growth, and further markings for growth were made on September 4th and October 27th. The results were as follows:—

TABLE III.
CARROTS—GROWTH MARKINGS.

Date.	Nature of Observation.	Treatments.							
		A.	B.	C.	D.	E.	F.	G.	H.
July 29th ..	Germination	8 $\frac{3}{4}$	7 $\frac{1}{2}$	4	5	6	7	9	9
		9 $\frac{1}{4}$	8 $\frac{1}{4}$	4 $\frac{1}{2}$	5 $\frac{1}{4}$	6 $\frac{3}{4}$	7	10	9
September 4th	„	9 $\frac{1}{2}$	9	7 $\frac{1}{4}$	7 $\frac{1}{4}$	7	8	9 $\frac{1}{2}$	10
October 27th ..	„	10	9 $\frac{3}{4}$	9 $\frac{1}{4}$	9 $\frac{3}{4}$	9 $\frac{1}{2}$	10 $\frac{1}{2}$	10 $\frac{3}{4}$	11 $\frac{1}{4}$

The possible number of points in each case is again 12. It will be noted in the markings made on July 29th that both germination and growth markings may be divided into two groups (A, B, G, H high and C, D, E, F low) G, H and C, D respectively being the highest and lowest pairs.

This result appeared to be determined by the location of the plots in the experimental area, as for some quite unknown reason there was a sharply marked division in both germination and growth conditions between plots on the west and east halves of the area. No such difference has ever occurred on the plots in previous seasons with any crop. This initial difference persisted until harvest, although it will be noted from the marking on October 27th that the top growth of the originally poorer plots eventually became very strong.

At harvesting time the main difference between the plots on the two halves was possibly mainly one of stage of maturity, the growth of tops on the initially good area appearing more advanced.

Cropping Data. The crops were harvested during the week commencing November 30th, 1942. Yields of roots and tops were obtained and since the number of split roots was very large, percentages of sound roots were also determined. The results were as under:—

	Treatments.							
	A.	B.	C.	D.	E.	F.	G.	H.
Total Roots Tons per Acre . .	34.1	33.1	27.9	27.6	31.0	32.3	36.4	35.7

Significant difference at 5% point = 5.26 Tons.

Sound Roots as percentage Total	29.6	27.9	12.6	10.4	16.4	15.3	39.0	28.7
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Significant difference at 5% point = 10.27
at 1% point = 14.30

Total Tops—Tons per Acre . .	5.75	5.97	5.65	6.29	6.15	6.70	7.20	6.46
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Significant difference at 5% point = 1.16 Tons.

It will be noted that the data for total roots show the same grouping of the treatments as for the growth observations of July 29th, and for this reason the results cannot be accepted as reflecting true differences due to the manurial treatments. This relationship is also shown in the data for sound roots, where the unusual result is obtained that the highest total yields are associated with the highest percentages of sound roots. It would seem that such a result may be due to different growth cycles in the two groups, those in the G, H, A, B group being in advance of the C, D, E, F group.

This group differentiation is not shown in the data for tops, for which growth in the later group had apparently reached a similar state as regards weight to that in the early group.

Summary.

1. Manurial experiments on spring cabbages and carrots are described, in continuation of the rotations reported in Part II of this series.
2. Adjustments in the general manurial scheme are given.
3. The results for the spring cabbage crop emphasise the predominant need for nitrogen. Those for the carrots were rendered uncertain because of the operation of some factor which could not be determined. It was shown, however, that all manurial treatments produced high yields of carrots.

REFERENCE.

- (1) WALLACE, T., CROXALL, H. E., and PICKFORD, P. T. H. Manurial Experiments on Vegetable Crops. II. Effects of Farmyard Manure and other Manurial Treatments on Savoy and Early Potatoes. *Ann. Rept. Agric. and Hort. Res. Stn., Long Ashton*, p. 33, 1941.

FIELD EXPERIMENT ON THE MANURING OF POTATOES.

By T. WALLACE, H. E. CROXALL and P. T. H. PICKFORD.

The experiment described in this paper was carried out in 1942 on plots on the Research Station farm which had been used for a manurial experiment on black currants from December, 1927, to July, 1941.

The results obtained with the black currants for the period 1927-1937 have been described.(1) Briefly it may be said that, in the black currant experiment, farmyard manure treatment gave the highest yields; potash deficiency was the most serious problem; and deficiency effects also occurred in the later years where nitrogen or phosphorus was omitted.

In 1937, and in subsequent years, symptoms of magnesium deficiency were prevalent from July onwards on the leaves on all plots receiving fertilisers containing potash and also to a slight extent on the farmyard manure plots.

Chemical determinations made on leaves of the black currants taken from all the plots in the experiment in July 1939 confirmed the deficiencies of nitrogen, potassium and magnesium.(2)

The black currant bushes were removed from the plots immediately after the 1941 crop was picked and the potatoes were grown in 1942 without any further application of manures, so that the crop was grown on the residues from the black currant dressings.

The results for the crop yields of potatoes show similar features to those for the black currants in the later years of the experiment.

Cooking tests made on the potatoes revealed that quality was affected by the manurial treatments. A point of considerable practical importance brought out in these tests was that blackening of the cooked potatoes was associated with deficiencies of potassium and phosphorus.

Experimental.

The site on which the plots are located is level and the soil is a light, fine sandy loam.

Soil samples representative of three of the manurial treatments were taken on October 1937, after the black currant experiment had been in progress for 10 years. Chemical data for these samples are given in Table I.

TABLE I.

SOIL DATA, OCTOBER 1937—RESULTS ON AIR-DRIED SAMPLES.

	No Manure.		Farmyard Manure.		Complete Inorganic Fertiliser(N.P.K.)	
	Surface Soil. %	Subsoil. %	Surface Soil. %	Subsoil. %	Surface Soil. %	Subsoil %
Moisture	2.10	1.21	3.28	1.45	2.29	1.63
Loss on Ignition	7.59	3.06	7.54	3.30	6.89	2.74
Total Nitrogen	0.209	0.077	0.290	0.084	0.205	0.077
Available Potash (K_2O)	0.0077	0.0050	0.0117	0.0069	0.0179	0.0068
Available Phosphoric Acid (P_2O_5) ..	0.0087	0.0055	0.0588	0.0078	0.0304	0.0070
Carbonate of Lime (approximate values)	5.0	1.0	5.0	1.0	5.0	1.0

The data reveal the following points :—The surface soils are well supplied with organic matter under all three treatments. Lime is plentiful in all surface soils and subsoils. In the “no manure” samples the values for both potash and phosphate are low. Farmyard manure treatment had somewhat increased the potash value and had considerably raised the phosphoric acid status in the surface soil. It had also increased the total nitrogen content. The complete fertiliser had increased the potash value more and the phosphoric acid value less in the surface soil than farmyard manure and had not affected the content of total nitrogen.

Subsoil values were not appreciably affected by the manurial treatments.

It is of interest to note the low values for potash and phosphate for the “no manure” plots since these suggest that these nutrients are likely to be deficient where they are omitted from the manurial treatments.

The area occupied by the plots forms a rectangle 60 yds. x 42 yds. It is divided into 18 plots, each 14 yds. x 10 yds. ($\frac{1}{3.5}$ acre approx.), and the plots are arranged in three rows of six plots. In the black currant experiment there were six manurial treatments, randomised in each row, and each row formed a manurial block.

The manurial treatments given annually to the black currants from 1928 to 1941 were as follows :—

Treatment A. No manure.

Treatment B. Farmyard manure at 10 tons per acre.

Treatment C. Complete fertiliser (N. P. K.) consisting of nitrate of soda 4 cwt., superphosphate 3 cwt., sulphate of potash 3 cwt.

Treatment D. As C, but omitting nitrate of soda (P, K).

Treatment E. As C, but omitting superphosphate (N, K).

Treatment F. As C, but omitting sulphate of potash (N, P).

In addition to these treatments sulphate of magnesia (30% MgO) at 4 cwt. per acre was applied to all plots in Block II in the spring of 1940 and 1941 in

order to observe the effect of this treatment on the incidence of magnesium deficiency symptoms.

The potatoes used in the experiment were of the maincrop variety, Dunbar Rover. They were planted on April 27th, and as mentioned previously no manurial treatment was given, as it was desired to determine the residual effects of the treatments given to the black currants. The usual cultural practices were followed.

The crops were lifted by ploughing out and harrowing during the period October 19th–22nd.

Results.

Field Observations. From an early date it was noted that the growth of haulm was poorer in all blocks in Plots A and F where potash is omitted. On July 1st, although growth was distinctly poorer on these latter plots than on the others, leaf symptoms of potassium deficiency were still scarcely apparent. On Plots C, D and E in Blocks I and III occasional symptoms of magnesium deficiency were evident.

The plots were marked for growth and leaf symptoms on July 29th, when the following results were obtained :—

TABLE II.

Treat- ment.	Block I.		Block II.		Block III.		Totals* for growth
	Growth.	Deficiency Symptoms.	Growth.	Deficiency Symptoms.	Growth.	Deficiency Symptoms.	
A	2	Potassium Slight	2½	Potassium Trace	2	Potassium Trace	6½
B	3½	Nil	3½	Nil	4	Nil	11½
C	3	Magnesium Slight	3½	Magnesium Trace	3½	Magnesium Slight	9½
D	3½	Magnesium Slight to Medium	2	Magnesium Trace	2	Magnesium Slight to Medium	7½
E	3½	Magnesium Slight	3½	Magnesium Trace	3½	Magnesium Slight to Medium	10
F	2½	Potassium Slight	3½	Potassium Trace	2½	Potassium Trace	8½

* Maximum possible 12.

It will be noted that growth was best on Plots B receiving dung and poorest on A, D and F, where the treatments are “no manure,” nitrogen omitted and potassium omitted respectively. There were no deficiency symptoms on Plots B; symptoms of potassium deficiency were just beginning to develop on Plots A and F; and symptoms of magnesium deficiency were present in slight to medium amounts in Blocks I and III in Plots C, D and E, and only as a trace in these treatments in Block II where magnesium sulphate had been applied in 1940 and 1941.

Later in the season both potassium and magnesium symptoms became very severe on the plots on which they are shown above, but as regards the magnesium type the relative orders between blocks and plots remained as for July 29th. Magnesium deficiency symptoms developed on Plots B during August, but the severity of the symptoms was never more than slight.

Crop Yields. The crop was harvested during the period Oct. 19th–22nd.

The data for total crop, ware and percentage ware of total crop for the various treatments are as follows, yields being given as tons per acre :—

TOTAL YIELDS.

Treatments	A.	B.	C.	D.	E.	F.
	7.84	14.17	10.64	9.23	9.43	8.32
Significant difference at 5% point, 2.63 ; at 1% point 3.74.						

YIELDS OF WARE.

Treatments	A.	B.	C.	D.	E.	F.
	7.03	12.35	9.36	8.37	8.17	7.04
Significant difference at 5% point, 2.51 ; at 1% point 3.56.						

WARE AS PERCENTAGE TOTAL.

Treatments	A.	B.	C.	D.	E.	F.
	88.3	87.2	87.9	89.8	86.6	84.6

The significant differences shown in total yields and ware are as follows :
 Total yield : B > A, D, E, F at 1% point, and > C at the 5% point ;
 C > A at the 5% point.

Ware : B > A, D, E, F at 1% point and > C at the 5% point.

In both sets of data the superiority of the farmyard manure treatment over the others is shown and in addition the complete fertiliser comes next to the farmyard manure and potash deficient plots are lowest.

The data for percentage ware in totals show that the fertiliser treatments have not affected this point significantly.

The differences between blocks were not significant and hence the data show no significant effect of the magnesium sulphate treatment given to Block II on crop yield.

Cooking Tests. In these tests a random sample of potatoes was taken from each plot and treated as follows :—

Freshly peeled tubers were placed in boiling water and boiled for 25 minutes, this period being ascertained by trial as the optimum period for samples from all plots in Block I. The cooked tubers were drained and placed on plates to cool. Condition was judged after standing 15 minutes and again after 24 hours. In making the tests, in order that results for the treatments should be comparative, tubers from the six treatments comprising a block were cooked simultaneously.

The quality of the cooked samples was assessed by three experienced judges from the staff of the Domestic Preservation Section of the Station, each giving an independent judgment. Score cards were prepared for external appearance, colour, consistency of flesh and flavour, 5 points being the maximum for each character, making a possible total of 20 points for each sample. The points given by the three observers for the various samples generally showed close agreement so that it is felt that where differences between samples are shown in the averaged markings they are likely to represent real differences.

The total markings for each plot are summarised in Table III. The total possible for each was 80.

TABLE III.
SUMMARY OF TOTAL POINTS AWARDED IN COOKING TESTS.

Blocks.	Treatments.						Block Totals.
	A.	B.	C.	D.	E.	F.	
I	27	41	38	43	31	21	201
II	30	18	34	36	32	23	173
III	32	31	35	45	29	27	199
Treatment Totals	89	90	107	124	92	71	

Treatment D, nitrogen omitted, was agreed by all to possess the best qualities and treatments A and F, where potassium is not given, the poorest.

Treatment B, occupies a relatively low position mainly because in the Block II sample the flesh collapsed to a pulp and in the Block III sample the texture again was unsatisfactory. The low position of Block II in comparison with Blocks I and III was due to the poor result with the Treatment B sample.

The results for colour and flavour are of special interest. The total points for these are given below to illustrate the outstanding points.

Treatments :	A.	B.	C.	D.	E.	F.
Colour	19	33	33	31	22	12
Flavour	23	24*	24	33	18	14

* Denotes low because of one pulpy sample.

Colour was outstandingly poor in the three Treatments F, A and E. blackening occurring in all three cases and being especially pronounced in F. It would thus appear that blackening developed when either potassium or phosphorus was deficient and was aggravated when nitrogen and phosphorus were applied in the absence of potassium. The parts played by nitrogen and phosphorus respectively in this latter case cannot be determined from the data.

As regards flavour, Treatment D was outstanding for excellence and Treatments F and E for poorness.

The results for colour and flavour thus indicate the importance of ensuring supplies of both potassium and phosphorus, and of using nitrogen with caution when these points of quality are unsatisfactory.

Summary

1. Potatoes were grown on plots in 1942 on which a manurial experiment on black currants had been in progress over the period 1927-1941. No manures were applied to the potatoes so that they were grown on the residues from the applications made to the black currants.

2. Leaf symptoms of deficiencies of potassium and magnesium were prevalent on the plots, the former where potash had not been given to the black currants and the latter where potash had been applied. Magnesium

deficiency symptoms were less evident where farmyard manure had been given and where dressings of magnesium sulphate had been applied in 1940 and 1941.

3. The highest yields were obtained on the farmyard manure plots and the lowest where potash was not given.

4. Cooking quality was adversely affected by deficiencies of potassium and phosphorus and these deficiencies were associated with blackening. The highest quality resulted where nitrogen was omitted from the complete fertiliser.

Acknowledgment.

Thanks are due to Miss B. A. Crang and her staff for carrying out the cooking tests.

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NOTE ON THE COMPOSITION OF LEAVES FROM POTATO MANURIAL EXPERIMENT.

By J. O. JONES and WM. PLANT.

A full account of this manurial experiment is given in the preceding paper. The following chemical analyses (Tables I and II) were carried out on leaf samples collected on July 14th.

At the time of sampling, treatments A and F in all blocks were just commencing to show potassium deficiency symptoms whilst magnesium deficiency symptoms were noticeable in C, D and E of Blocks I and III and to a less extent in II.

Table I shows the mean estimations of the three blocks representing the ash and chief nutrients as a percentage of the dry matter.

TABLE I.

Treatment.	Results as Percentage of Dry Matter.					
	Ash	CaO	MgO	K ₂ O	P ₂ O ₅	N
A. No manure ..	18.52	4.70	0.82	4.23	0.80	4.6
B. F.Y.M. ..	19.87	4.32	0.77	7.05	0.97	4.9
C. N.P.K. ..	20.48	4.03	0.36	7.23	0.82	5.3
D. P.K. ..	20.32	4.05	0.38	7.82	0.82	4.4
E. N.K. ..	19.56	3.87	0.37	8.19	0.76	4.7
F. N.P. ..	18.58	5.49	1.23	3.60	0.81	4.7
Significant difference 5% point ..	0.84	0.12	0.13	0.78	0.05	Not significant

The chief points of interest are as follows :—

The effect of treatment on the amounts of ash, CaO, MgO, K₂O and P₂O₅ present is significant.

Comparing treatments :—

- Ash : B, C, D and E are significantly higher than A and F.
- MgO : C, D, E and F are significantly lower than A and B.
- K₂O : B, C, D and E are significantly higher than A and F.
- P₂O₅ : A, C, D, E and F are significantly lower than B.
B, C, D and F are significantly higher than E.

The low potassium content of the leaves from plots A and F showed a relative deficiency at this stage of growth, more so than was apparent from the leaf symptoms.

The low magnesium content of C, D and E, all receiving potash in inorganic fertiliser mixtures, corresponded with the deficiency symptoms on the foliage. In order to appreciate the increased uptake of magnesium due to two dressings of sulphate of magnesia (1940-41) applied to Block II the individual block estimations are given in Table II.

TABLE II.
MgO AS PERCENTAGE OF THE DRY MATTER.

Block.	Treatments.					
	A.	B.	C.	D.	E.	F.
I. ..	0.87	0.67	0.27	0.35	0.33	0.92
II. ..	0.81	0.84	0.53	0.54	0.51	1.42
III. ..	0.77	0.80	0.27	0.26	0.28	1.31

In plots C, D and E of Block II where deficiency symptoms were less evident than on Blocks I and III the magnesium figures are higher. It should be noted, however, that a still higher uptake is necessary before such a plant is receiving an amount consistent with optimum nutritional standards.

Summary.

1. Determinations of ash and nutrients expressed in terms of dry matter were made on potato leaves taken from manurial treatments involving the use of inorganic fertilisers and dung.
2. The effect of treatment is shown to be significant in the case of the ash, calcium, magnesium, potassium and phosphorus contents. Significant differences between treatments are indicated.
3. Deficiency symptoms of potassium and magnesium are found to agree with the chemical analysis of the leaves.

Acknowledgment.

The estimation of calcium, magnesium and potassium was carried out on the spectrograph by the kind permission of Dr. J. B. Hale, of Rothamsted.

A NOTE ON HEART-ROT IN SUGAR BEET IN HEREFORDSHIRE.

By D. A. OSMOND.

In the late summer of 1942, instances of heart-rot in sugar beet due to boron deficiency were observed in Herefordshire. The number seen was such as to make it worth while carrying out a survey of parts of the county to determine the extent of the trouble and to obtain soil samples for investigation.

With the assistance of the Advisory Officer and two of the District Officers of the War Agricultural Executive Committee visits were made to some of the sugar beet fields. It was not possible to sample all the fields seen at the time, but the soil samplers of the Land Fertility Scheme obtained samples from some of them at a later date.

The investigation has shown that heart-rot of sugar beet due to boron deficiency was fairly widespread in Herefordshire and that it is associated with soils having a small amount of water-soluble boron together with a high content of calcium carbonate.

Symptoms of Heart-Rot.

The symptoms begin to appear about the time when the plants are singled. Mild cases of boron deficiency in sugar beet are manifested by cracking and splitting at the base of the leaf stalks, frequently associated with a black or dark brown "ladder-like" series of ridges across their upper surfaces.

In instances of severe deficiency the central crown leaves die and turn black, owing to the later entrance of a fungus disease. If the root continues to grow, it does so round the dead centre producing the familiar "hollow crown" or "heart-rot."

When heavy dressings of nitrogenous manures are given soon after the "hollow crown" symptoms are evident, the plants are frequently forced into vigorous secondary growth around the crown and to casual inspection the field may appear normal. This was particularly noticeable at centres J1 and J2.

Centres Investigated.

In the area between Hereford and the southern boundary of the county twenty-seven fields were visited and only at eight were any symptoms seen. Of these, five were very severe and would cause considerable losses of crop, while in the remaining three instances the symptoms were only slight.

In the area Leominster—Eardisley—Kington, eleven fields were visited, and in six the symptoms indicated that some loss of crop would occur and only one showed a slight evidence of the trouble.

Three fields were seen in the vicinity of Hereford, only one of which was showing severe symptoms, and in one instance the disorder had been overcome by the application of borax at the rate of 12-14 lb. per acre.

In all, forty one fields were visited and heart-rot in varying degrees of severity were noted in seventeen, *i.e.* 41%.

Soils.

Field Characters. At five centres, A1, B1, D1, A2 and D2, the soils are of the Ross series. The profiles show about 9" of reddish-brown, loose, fine sandy light loam, becoming more sandy with depth until at 18" coarse sand is the dominant fraction, although the soil at this depth is more compact. Drainage is free in the upper 18", and during a hot, dry period the soil may dry out to some depth. Both "good" and "bad" patches were found on this soil series.

At three centres, E1, E2 and C2, the soil is a variant of the Ross series and consists of 9" or 12" of red-brown coarse sand with many fragments of conglomerate. At 12" or deeper the coarse sandy rock or conglomerate appears. This soil usually occurs on the brow or slope of rather steep slopes and is associated with some of the worst cases seen; it dries out early in the season.

Soils derived from a drift composed mainly of Old Red Sandstone with some material of Silurian origin occurred at the remaining thirteen centres. Under conditions of good drainage the upper 9" is a reddish-brown, light to medium fine sandy loam with some Silurian stones on the surface. Below this the soil has a redder tint and the texture frequently becomes heavier. This soil was noted at four centres. At the remaining nine centres, drainage is not so good and the soil and subsoil have a greyer appearance and in the latter occasional brown mottling appears.

Chemical Data. In Table I are shown the calcium carbonate content, the pH value, and the amount of boron soluble in cold water of the soil samples, together with the severity of the symptoms observed.

TABLE I.

Centre.	Severity of Symptoms.	Ca CO ₃ %	pH.	Water sol : Boron p.p.m.
A1 ..	None	0.09	6.62	15.15
B1 ..	None	0.09	6.47	10.99
D1 ..	None	0.07	6.38	4.55
E1 ..	None	0.06	6.48	11.29
F1 ..	None	0.07	7.05	7.92
G1 ..	None	0.01	5.89	-6.05
H1 ..	None	0.02	4.83	7.42
J1 ..	Slight	0.09	4.98	6.44
K1 ..	None	0.01	6.40	4.16
L1 ..	None	0.01	6.23	4.95
M1 ..	None	1.19	7.63	10.59
N1 ..	None	0.02	6.84	7.52
Average values		0.14	6.32	8.09
A2 ..	Plants dying	1.83	7.95	3.86
C2 ..	" "	6.06	7.74	4.26
D2 ..	" "	1.45	7.74	4.26
E2 ..	" "	1.96	7.44	4.26
F2 ..	" "	0.11	7.28	5.16
H2 ..	" "	0.08	5.22	5.55
J 2 ..	Plants made much secondary growth	0.61	6.06	5.15
M2 ..	Plants dying	2.91	7.94	5.25
N2 ..	Severe	0.03	7.20	6.44
Average values		1.67	7.17	4.91

The calcium carbonate content of all the centres (except one) at which no symptoms were observed is below 0.1% (*i.e.* less than 1 ton per foot-acre); this is reflected in the pH values which, with two exceptions, are below 7. The amount of water-soluble boron ranges from 15.15 to 4.16 p.p.m. with an average value of 8.09 p.p.m.

Where the plants were showing very severe symptoms, the calcium carbonate content, except in two instances, is over 0.1% and frequently over 1% (*i.e.* 10 tons per foot-acre), and the pH values, except in two cases, are over 7.20. The water-soluble boron ranges from 6.44 to 3.86 p.p.m. with an average of 4.91 p.p.m.

Although the number of centres is small, it is clear that heart-rot is associated with (1) a low water-soluble boron content, and (2) a relatively large amount of calcium carbonate in the soil coupled with pH values usually over 7.0. Where no symptoms were observed, the amount of water-soluble boron is higher and of calcium carbonate very much lower.

A further factor in the production of the symptoms is the water-supply in the soil, and the deficiency has been observed in pot experiments under conditions favouring either drought or poor aeration (1) which frequently occurs with poor drainage. Instances of these former conditions were seen at centres C1 and E2 and of the latter at H2.

Recommendations.

It is recommended that farmers intending to lime for sugar beet on these types of soil should have the soil tested beforehand and, the application of heavy dressings of lime just before planting is not generally advisable. Where lime must be given, it is possibly better to apply it at some point in the rotation other than immediately prior to the sugar beet crop.

Acknowledgment.

Dr. W. Plant was responsible for the method of estimating the water-soluble boron in soils and for carrying out the analyses.

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A METHOD OF WASHING OUT WIREWORMS FROM SOIL SAMPLES.

By S. H. BENNETT and H. G. H. KEARNS.

The examination of soil samples for wireworm larvae and other insects may be carried out by hand manipulation of the soil or by washing processes (1) Hand manipulation is more subject to inaccuracies and the variations in results between individual examiners may in some instances be sufficiently large to preclude comparisons of data obtained by different individuals. The wireworm larvae cannot be detected unless they are exposed during the examination process and the chances of exposure depend on the physical condition of the soil and the skill of the examiner in its manipulation. The percentage of wireworms detected within a sample therefore depends on the efficiency of the method of exposure and collection, and the observational accuracy of the examiner. The errors due to lack of exposure are greater than those of faulty observation and therefore a method that standardises the chances of exposure is desirable for comparative studies of wireworm populations.

Since June, 1940, a method of sorting out wireworms by a washing process has been employed at Long Ashton for the analysis of soil samples. The equipment was designed for the rapid examination of large numbers of 4" core samples for wireworms of 5 mm. length and greater. Since then the advantages of extracting wireworms from soils by washing processes has been more fully appreciated and equipment has been designed by Salt and Hollick and by Petherbridge and Stapley.

The Equipment.

Wireworms are fairly readily sorted out from light soils by washing but clays are much more resistant to breaking down processes. The more a clay soil is handled wet the greater the tendency to become intractable. It is for this reason that it is often impracticable to break up a clay soil by rotating it, a method that is excellent for light friable soils.

A simple method of dealing rapidly with a wide range of soils consists of washing the soil through sieves by means of medium pressure water. A nest of four sieves of 14"-16" diameter are fitted together, graded for size with the hoops of the smaller sieves fitting into the larger with a 3" space between each sieve. The coarsest mesh sieve is at the top and the finest at the bottom. The particulars of the meshes are as follows:—

1st sieve	8 mesh per linear inch	3.0 mm. aperture.
2nd	16 " " " " "	1.1 " "
3rd	20 " " " " "	0.82 " "
4th	30 " " " " "	0.6 " "

The wire of the mesh is round in section.

The sieves consist of galvanised iron hoops fitted with copper or brass gauzes. It is necessary to tin the gauzes so that corrosion is reduced at the point of contact with the iron hoop. Painting the hoops and gauzes with white synthetic resin enamel assists in the detection of the wireworms collected on the sieves but the paint is fairly rapidly damaged by the friction of the soil and water.

The nest of sieves is placed on an iron frame covered with 1" wire netting and the soil sample is washed through the sieves by means of a manually-

operated, short spray gun fitted with a disc of $4/64$ ths in. The pressure of the water should be 150-200 lb. per sq. in. and the output approximately 3 gallons per minute.

The washings from the sieves should drain into a sump to enable as much as possible of the silt to settle out before the water passes into a drainage system.

In addition to the above, pails are necessary for soaking the soils in water before washing and bins, 24" diameter, to hold 20 per cent. sodium chloride solution. The bins should be painted inside and out with bituminous paint to prevent corrosion.

Well placed electric light is necessary for the detection of the wireworms on the sieves.

The water under pressure is supplied from a high pressure pump with an adequate water supply for continuous operation.

Procedure of Operation.

The soil samples used were collected in small hessian bags in the field and examined at Long Ashton.

Each sample was soaked in water for 12-24 hours before washing and examined individually. Turf layers where present, were removed and treated separately as they required hand manipulation on the sieves to ensure that all the wireworms were exposed to the washing jet. The whole or part of each sample was spread over the top sieve, the amount used depending on the physical condition.

The number of sets of sieves and guns used depends on the number of examiners. Three operators, two using guns and one observing, were able to prepare and examine on an average 200 four-inch cores soil in six hours. Each sample required from 1-3 galls. of water.

The action of the medium pressure water jet is to force the soil through the mesh of the sieves, the cross mesh of the sieves acting as a cutter and forming a characteristic shaped soil residue. The wireworms, even the 5 mm. size, do not suffer undue damage and although the diameter of the wireworms permit them to pass through the 20 mesh sieve a high percentage remain across the mesh of the sieve, and for this reason the use of the 30 mesh sieve was frequently omitted. The 8 mesh sieve removes stones and organic debris and allows the wireworms to pass through. The 20 and 30 mesh sieves are placed in the salt solution for examination and the wireworms float to the surface of the liquid.

At times, especially with clay soils, the finest sieve becomes clogged unless the spray jet is applied to it directly instead of through the other sieves. It is desirable to avoid pressures in excess of 200 lb. per sq. in. as there is a danger of causing the soil in the top sieve to splutter over the edge of the sieve.

This method of analysis is intended for advisory work and it is unsuitable for critical soil population studies.

Acknowledgments.

Thanks are due to Messrs. C. H. Hoddell, L. E. W. Stone and A. Stringer, who used the equipment for long periods, for their helpful criticisms.

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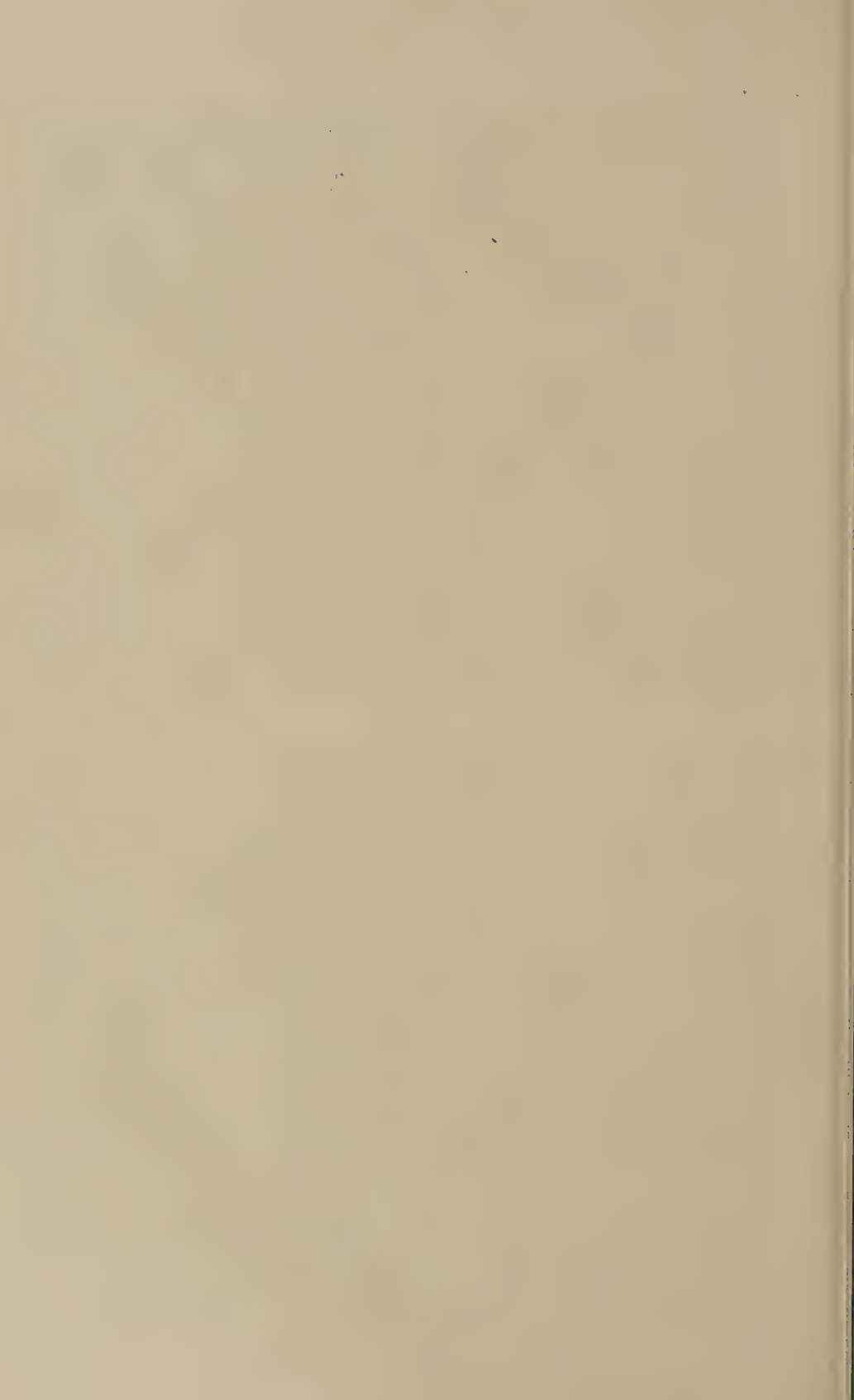
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PLATE I.—The equipment used for washing the soil samples.



PLATE II.—Floating off wireworms from debris by means of salt solution.



INVESTIGATIONS ON THE DESTRUCTION OF MOLES*

POISON BAIT.—Abridged Report.

By S. H. BENNETT, H. G. H. KEARNS, A. W. LING and N. G. MORGAN.

The status of the mole in agriculture is a matter of controversy. In Germany this rodent is considered as beneficial and it is protected by law because its diet includes soil insect pests. It appears probable that undue importance has been attached to this fact because the food of the mole consists almost entirely of earthworms. Insects such as the larvae of the cockchafers and wireworms are only incidental food and they are only consumed if they happen to be found during the burrowing operations of the mole.

In Great Britain the mole is almost universally regarded as a pest. It increased in numbers considerably during the years before the present war, partly as a result of the ever-increasing acreage of indifferently farmed pasture land and partly by the almost total disappearance of the professional mole catcher.

The damage on grassland consists of the obvious eruptions of numerous earth hills which interfere with mowing and kill out in a severe infestation considerable areas of grass. If the hillocks are left undisturbed they are often invaded by ants and become consolidated and enlarged. A less obvious but equally serious form of injury is the formation of numerous surface burrows in the turf. Over a period of years a severely infested pasture becomes a maze of surface burrows which reduce the quality and quantity of the grass, especially in times of drought. Moles are primarily pests of grassland but they cause serious damage in seed beds and crops in market gardens. Generally the infestation of arable land occurs when it adjoins grassland. Moles are also troublesome on arable land that has been recently broken, though the infestation decreases fairly rapidly if the land remains under cultivation. The edges of arable fields adjoining grassland and coppices are often subject to yearly attacks. Raised banks on the sides of streams and rhynes often support a heavy population of moles. Their extensive tunnelling may weaken the banks of high level drainage channels by allowing the water to wash away quantities of the soil.

The activity of moles is linked up with earthworm population and the system of burrows is designed for the capture of this kind of food. The mole does not tunnel at any great depth in the soil to obtain earthworms mainly on account of the difficulty of forcing its way through compacted soil.

It prefers a soil that can be fairly readily compressed during tunnelling. An obstruction such as hard earth, stones, roots, etc., in its path results in the need for greater digging and a hillock is thrown up. The presence of a large number of hillocks on grassland does not appear to be necessarily an

* The investigations were carried out under a special grant received from the Ministry of Agriculture and Fisheries 1939—1941.

indication that there is a large mole population. Thus on thin soils on Chalk Downs numerous shallow hillocks are thrown up in spring but the catch of moles is often small, whereas on a moist loam the proportionate catch is very much higher.

Early spring and autumn are the two periods in which the greatest amount of fresh earth hillocks are thrown up. This is partly due to the moist conditions of the soil at these times of the year, which make extensive burrowing easy whilst the earthworms are in the top few inches of the soil. During summer, when the soil dries out and earthworms in the top layers of the soil become scarce, mole activity as expressed by the formation of hillocks becomes less obvious. The conditions do not result in deep burrowing of the moles but often in a movement to land with more suitable soil conditions where earthworms can be obtained more readily. The movements of the moles can be followed by the formation of hillocks. Thus on the Chalk land in Wiltshire the movement during the drier months is downhill to the moister valleys or to pockets of relatively deep, damp soil and sometimes a high population is built up in a restricted area. In another instance, on Tickenham Hill, near Clevedon, Somerset, a narrow strip of sloping market garden land, with a South-West aspect and approximately three miles long by 250-700 yards wide, is situated between a wooded hilltop at 300 feet elevation and low moorland at 15 feet elevation. Each spring the moles are in numbers on the fringes of the woodland at the top of the hill, and as the season advances and the soil dries out the moles move downhill to moister soil conditions and become widely dispersed on the moor. In September and October they return to the higher ground. The movement may cover as much as half a mile or more. During winter floods the mole population on the higher ground is greatly increased and it is followed by devastating mole damage in the spring.

Toxicity of Poison Baits.

An investigation of the lethal properties of chemical preparations necessitated the feeding of poison baits under controlled laboratory conditions. After numerous technical difficulties successful methods of trapping live moles and of keeping them alive in captivity were evolved.

Preliminary experiments with well-known poisons, such as the arsenicals, gave inconsistent results, and it was found that the mole's method of feeding and the nature of its food were responsible for these variations. Observations showed that under natural conditions the diet consists almost entirely of earthworms. The worms are captured in the main runs (runs used by several moles) and in surface feeding runs (often only used once), and they are invariably consumed in a special manner. The worm is seized by the front fossorial claws of the mole and one end is bitten off. The worm is then rapidly consumed progressively from one end to the other and during this procedure, the claws wipe the surface of the earthworms free from particles and remove, by squeezing, much of the earthy contents of the alimentary tract. This habit of feeding has considerable bearing on the consumption of a poison bait under natural conditions. For example, insoluble poisons, such as some of the arsenicals, applied as a powder to the skin of the earthworm, were almost entirely removed and insoluble poisons inserted into the alimentary canal of the earthworms were largely removed as foreign bodies or the bait was rejected.

Under laboratory conditions moles consume worms dead and alive and whole or in portions, also rabbit and other meat in large pieces or shredded. Under natural conditions, however, they refuse to eat any baits other than whole or cut earthworms. The habit of feeding under laboratory conditions on meat in various forms, such as whole pieces or shredded, made it possible to ascertain the toxic properties of a number of preparations, including strychnine sulphate, brucine sulphate, red squill powder and extracts, barium salts, fluorides, cyanides, oxalates, metaldehyde, dinitro-ortho-cresol and its copper salt, arsenicals, nicotine and its salts, etc.

The minimum lethal dose of strychnine sulphate was between 0.5—1.0 mg. per mole (*i.e.* 28,000—56,000 moles per oz.), and death occurred in 15—20 minutes after consumption of a bait. A 10 mg. dose caused death within 3—10 minutes.

Brucine sulphate, an alkaloid of similar properties to strychnine, but of reported lower toxicity to domestic animals when taken orally, was examined and the minimum lethal dose was found to be 50—100 mg. per mole. The minimum lethal dose of arsenic pentoxide was between 10—15 mgs. Red squill in its various forms proved to be a repellent even when tested under conditions that favoured consumption. Under laboratory conditions it was possible to ensure that a mole consumed a minimum lethal dose of several of the preparations by offering several separate baits in a short period of time. This additive method of acquiring a lethal dose under natural conditions would be extremely unlikely to occur. Field experiments showed that it was essential that each separate bait contained a considerable excess of the minimum lethal dose, because there was no certainty of a mole consuming the whole bait let alone more than one bait.

Method of Using a Poison Bait.

Field experiments showed that strychnine sulphate was the only chemical that had the necessary properties to prepare a successful worm bait that would be both attractive and deadly to moles.

The conditions of using strychnine sulphate baits under field conditions were determined. It is necessary to employ considerably larger lethal dosages than those found sufficient under laboratory conditions, and ten times the lethal dosage was found to be satisfactory. A bait consisting of 50 parts by weight of fresh earthworms to one part by weight of strychnine sulphate was used. Each bait consisted of a two-inch length of a medium sized earthworm. One thousand baits were prepared from 500 gm. ($17\frac{1}{2}$ ozs.) earthworms and 10.0 gm. ($\frac{1}{3}$ oz. approx.) strychnine sulphate. Each acre of badly infested pasture land required a minimum of 10 baits.

It was found that a relatively small number of moles were able to form a large number of earth hillocks (dumps), and care was necessary to place the baits in the main runs which are used by a number of moles. These runs are relatively shallow in the soil and the walls of a run are compacted by constant use and an experienced mole catcher can readily detect them. The runs may continue for considerable distances without any or only a few hillocks along their path. From them subsidiary side runs occur, often with many hillocks above them. There seems no hard and fast rule concerning the lay-out of the runs, the main ones interconnect and subsidiary ones may become main ones.

They are more readily seen near hedgerows and across gateways, and once detected they may be traced by the poorer quality of the grass above it, especially evident in dry weather.

The baits must be placed in the main runs carefully to ensure that a high percentage are consumed. The run is opened by a small spade and exposed to view and a bait inserted at least six inches into the open run by means of a pointed stick or long forceps. The earth is then placed back fairly firmly into the spade hole, taking care to prevent the soil entering the portion of the run containing the bait. In due course the blockage in the path of the run is cleared by a mole and it consumes the bait *en route*. The experimental field work in which this method was evolved was carried out in loams, and difficulties may be met in finding the runs on light soils, especially on this flinty soils.

The first baiting in some instances gives immediate results and is shown by the absence of new dumps which are normally thrown up daily when the soil is moist. The baiting should be continued until the appearance of fresh dumps ceases.

The bait is prepared by digging earthworms from suitable sites, such as moist ground containing plenty of humus, *e.g.* old sites of farmyard manure heaps.

The worms are cut up into lengths of about 2 inches and the strychnine sulphate crystals shaken over them. Care must be used to distribute evenly the relatively small weight of crystals to ensure that each bait carries a sufficient amount of the poison. The baits must be used within six hours of preparation, and in every instance it is preferable to use freshly prepared baits.

Time for Baiting.

The best time for the use of baits is when the moles are actively engaged in throwing up hillocks. This activity occurs when the soil is in a suitable condition to enable burrowing to proceed easily. Considerable activity takes place from March until June and again in Autumn. In Spring the moles are breeding and distributing themselves over a wider area of ground in search of food, and in Autumn they tend to concentrate more together on the higher and better drained ground. Their movements are largely dependent on the moisture content and earthworm population of the top layer of the soil. Observations on the seasonal movements of the moles makes it possible at times to use local conditions to advantage so that the maximum results are obtained from the minimum effort in baiting.

The successful destruction of moles depends on a practical knowledge of its habits, and it is doubtful if satisfactory results can be obtained by casually carried out control measures.

The extremely poisonous nature of strychnine sulphate to man (the minimum lethal dose is quoted between 20 mg.—220 mg.) and to animals and the need for skill in its application suggests that the work should be carried out by professional mole destroyers. Very few skilled mole catchers exist in the country, as judged by enquiries in the West Country, and it should be noted that a distinction must be made between mole catching and mole destruction. The skilled professional mole catcher avoids killing out a mole

population in an area favourable to moles as he obviously would destroy his own livelihood. It is recommended that professional mole destroyers should be trained and reasonable remuneration offered for their services.

Summary of Results.

The investigations carried out were confined to an examination of methods of destroying moles and more especially by means of poison baits.

Preliminary experiments on methods of destroying moles included trapping, gassing and the use of poison baits. Trapping, although satisfactory, required skill and persistent attention to reduce a mole population to a negligible quantity, and it is not suitable for general recommendation to farmers unless they or their staff are interested in the work and have the necessary time available.

The use of calcium cyanide dust, as a source of hydrocyanic acid gas, proved impracticable.

Poison baits provided the most satisfactory results, as they were quickly applied and did not demand great skill to use. Of the various poison baits recommended and commonly used red squill was useless, the arsenicals of doubtful value and strychnine sulphate highly successful.

Professional mole catchers in the past have used strychnine and strychnine sulphate in an empirical manner as a poison bait. Critical information on its behaviour or application did not appear to be available, but experiments suggested that much of the success of the mole catcher in ridding land of moles was due to its use. Unfortunately strychnine and its salts are highly poisonous to man and domestic animals, and their lethal action is so rapid that the chances of successfully treating a case of accidental poisoning are not great. It is therefore desirable if possible to find a satisfactory but less dangerous poison.

A PRELIMINARY TRIAL OF NEW COPPER FUNGICIDES ON OUTDOOR TOMATOES.

By R. L. WAIN and E. H. WILKINSON.

Introductory.

The cultivation of outdoor tomatoes has markedly increased since the outbreak of war. After the serious attack by Blight (*Phytophthora infestans*) in 1941 most growers of this crop realised the importance of frequent and adequate applications of copper sprays to prevent loss by this disease. Bordeaux mixture and various proprietary copper compounds have been advocated for this purpose although very little has been published concerning the control of Blight on tomatoes in England.

As a result of investigations upon numerous copper fungicides (1), the writers selected two pure copper compounds which could be made available commercially and in a series of intensive laboratory tests had shown themselves to be equal in fungicidal value to Bordeaux mixture.

A small scale trial was carried out in order to investigate the field performance of these substances, in particular their ability to control *P. infestans* and their tenacity and phytocidal action.

Materials and Methods.

The compounds selected were :—

1. Copper sebacate, 23.87% Cu.
2. Cupric cuprimalate A, prepared from pure *dl*-malic acid, 31.73% Cu.
3. Cupric cuprimalate B, prepared from crude *l*-malic acid* extracted from apple treacle, 29.09% Cu.
4. 4:4:50 and 4:4:100 Bordeaux mixture.

All suspensions were sprayed at 0.1% Cu. and the Bordeaux mixtures used corresponded to 0.1 and 0.2% Cu. No dispersing agents were employed.

The Bordeaux mixture was prepared and applied immediately. The other sprays were made up in the laboratory by triturating the required amounts of compound with water.

The treatments were randomised and carried out on duplicate plots, each plot consisting of 12 plants of the variety "Market King" in two rows. At each time of spraying, 1 gallon of fungicide was applied per plot with a hand-operated "Solo" sprayer. Good cover of both upper and lower sides of the leaves was obtained.

Dates of Application.

(1) *August 12th.* Plants had 1 to 3 trusses either set or in flower. Weather was ideal for spraying. The deposit dried quickly giving an even cover. Much rain fell between this and the second application.

(2) *August 27th.* Plants were growing vigorously. Weather was very hot and ideal for spraying.

* Supplied as crude calcium malate by the Fruit Products Section of this Station.

(3) *September 14th.* Majority of plants had been "stopped" after the fourth truss. Weather was calm and dry.

Observations were made at frequent intervals until October 14th.

Copper Retention.

Samples of leaves were taken on September 11th and September 15th for copper determinations as described by Martin (2).

Results.

Blight Control. No evidence of Blight was observed in this trial except on September 24th, when one blighted fruit was found in a control block. This result was unexpected for the weather was favourable for Blight which had, in fact, become widespread in the district.

Copper Damage. Copper damage was noticed after the second application and onwards on the plants which had received Bordeaux mixture at 0.2% Cu. This took the form of bronzing of small areas of the leaf surfaces. Slight damage of a similar nature appeared also after the third application on the plants sprayed with Bordeaux mixture at the lower concentration. No damage occurred on plants which received the other treatments.

Copper Retention. The first samples of leaves for estimation of retained copper were taken 15 days after the second application from foliage which had withstood heavy rainfall during this period. The second sampling was made on the morning after the third application, some rain having fallen during the night. Most analyses were made in quintuplicate except for the controls which were made in duplicate (Table I).

TABLE I.

COPPER RETENTION EXPRESSED AS MG. CU. PRESENT ON 50 LEAF DISCS OF DIAMETER 1.5 CM.

Treatment.	1st Sampling. Sept. 11th.	2nd Sampling. Sept. 15th.
Cupric cuprimalate A	0.28 $\pm$ 0.074	1.46 $\pm$ 0.451
Cupric cuprimalate B	0.35 $\pm$ 0.051	1.16 $\pm$ 0.207
Copper sebacate	0.495 $\pm$ 0.014	1.28 $\pm$ 0.296
Bordeaux Mixture 0.1% Cu. .. .	0.71 $\pm$ 0.313	1.53 $\pm$ 0.498
Bordeaux Mixture 0.2% Cu. . . .	0.79 $\pm$ 0.236	3.04 $\pm$ 0.684
Control	0.075 $\pm$ 0.035	0.19 $\pm$ 0.028

Discussion.

The results establish the fact that at the concentrations used, none of the new copper fungicides are damaging to tomato foliage or fruit. The non-appearance of Blight except on one fruit in a control block prevents an assessment of the protective value of these substances in the field.

No difficulty was met in maintaining and spraying the suspensions, and

in obtaining a uniform cover. Copper sebacate gave a most conspicuous deposit which, however, could be rubbed from the fruit without difficulty. The cuprimalate deposits were not clearly visible after drying.

The figures for copper retention (Table I) show that, while Bordeaux mixture is superior in this respect, copper sebacate withstood weathering well. A satisfactory deposit was retained with this compound as well as the cuprimalates. The rather high figure for the control plants after the second sampling is attributed to slight spray drift.

Acknowledgments.

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INVESTIGATIONS WITH VARIOUS COPPER COMPOUNDS IN RELATION TO "DAMPING-OFF" IN PEAS.

By R. L. WAIN and E. H. WILKINSON.

Introduction.

The control of "damping-off" by the application of insoluble copper compounds to pea seed has been widely recommended and is now a common horticultural practice. The most popular of these dressings is cuprous oxide in the red or yellow form and many investigations on the degree of control afforded by this substance have been made (*e.g.* 2, 3, 5, 6).

For the past three years the authors have studied the fungicidal action of copper, work which has involved the preparation of a large number of insoluble copper compounds in the pure state (4). Certain of these possessed physical and fungicidal properties which prompted a study of their value as seed protectants.

The present report gives an account of the results obtained to date.

Materials and Methods.

The compounds were selected to provide a range of efficient, mediocre and poor fungicides on the basis of fungicidal properties determined previously by critical tests (4). An examination of the relationships between fungicidal value and the control of pre-emergence "damping-off" thus became possible. From some 50 copper compounds the following were chosen:—

1.	Copper mucate, $C_8H_8O_8Cu$, $4H_2O$	..	..	..	..	19.28% Cu
2.	.. sebacate, $C_{10}H_{18}O_4Cu$	..	..	..	..	23.87% Cu
3.	.. sulphate, monohydrate, $CuSO_4, H_2O$	..	..	..	..	25.46% Cu
4.	.. adipate, $C_8H_8O_4Cu$	..	..	..	..	31.31% Cu
5.	.. succinate, $C_4H_4O_4Cu$	..	..	..	..	35.37% Cu
6.	.. phosphate, $Cu_3(PO_4)_2, 3H_2O$	..	..	..	..	45.26% Cu
7.	Cuprous thiocyanate, $CuCNS$	..	..	..	..	52.86% Cu
8.	Copper oxychloride, $CuCl_2, 3Cu(OH)_2$	..	..	..	..	59.61% Cu
9.	Red Cuprous oxide (proprietary), Cu_2O	..	..	..	..	85.72% Cu
10.	Yellow Cuprous oxide (proprietary), Cu_2O	..	..	..	..	85.40% Cu

The varieties of pea seeds used were "Surprise," "Eclipse" and "Foremost," the first being known to be susceptible to "damping-off," and "Eclipse" being sensitive to copper damage (1).

Optimum conditions for the production of copper damage, assessed by the percentage emergence in sterile soil, were obtained by controlled watering. The non-sterile soil, however, was well watered so that "damping-off," known to be most severe in wet soils, would be encouraged. The percentage emergence in this soil was taken as an indication of the control of "damping-off."

In the first experiments described, the above compounds, finely ground, were made into dressings by the addition of talc to bring the copper concentration to 19.28%, *viz.* the copper content of copper mucate. This compound was therefore used undiluted.

Lots of 500 peas were placed in glass containers and 0.2% Cu referred to the weight of peas, was added. In each case this was found to be a slight

excess. The stoppered containers were then shaken mechanically for 15 minutes, the peas removed and separated from the superfluous dressing.

For each compound tested, 400 treated peas were planted 1" deep in 4 boxes of sterile and 4 boxes of non-sterile soil. The boxes were placed in randomised positions in an unheated greenhouse at a temperature not more than 60°F. Immediately after planting, each box of sterile soil received one pint of water whereas the boxes of non-sterile soil were treated with sufficient water to cause saturation.

Emergence figures were obtained by taking counts of visible plumules every 24 hours. These counts were continued until no further increases were observed.

In the second test the same technique was used to compare copper sebacate with copper phosphate and proprietary red and yellow cuprous oxides. The variety "Surprise" was used and the treatment consisted in shaking the peas with the undiluted compounds at the rates of 0.5, 0.25 and 0.125% by weight of the seed. 100 peas were used for each treatment. The excess of compound left in the glass containers, after the treatment of the peas, was weighed and from this the percentage adherence at each concentration was calculated.

Results from Germination Tests.

1. *At equivalent copper concentrations.*

Emergence was first observed on the 7th day after planting and was complete in 15 days.

TABLE I.

AVERAGE PERCENTAGE EMERGENCE IN STERILE AND NON-STERILE SOIL OF THREE VARIETIES OF PEAS TREATED WITH VARIOUS COPPER COMPOUNDS AT EQUIVALENT COPPER CONCENTRATIONS.

Treatment.	Surprise.		Eclipse.		Foremost.	
	Sterile.	Non-Sterile.	Sterile.	Non-Sterile.	Sterile.	Non-Sterile.
Copper mucate	89.5	75.0	86.5	93.0	98.0	87.5
Copper sebacate	92.5	82.5	85.0	82.5	100.0	96.0
Copper sulphate monohydrate ..	—	—	65.5	84.0	99.0	93.5
Copper adipate	93.0	79.5	79.5	81.5	99.5	89.5
Copper succinate	86.5	74.0	85.5	80.5	96.5	94.5
Copper phosphate	90.5	79.0	71.0	86.0	98.5	93.5
Cuprous thiocyanate	93.5	19.0	94.0	29.0	97.5	73.5
Copper oxychloride	91.5	69.5	90.5	79.5	97.0	88.5
Cuprous oxide (Red)	87.5	63.0	94.5	79.0	98.0	83.0
Control	90.5	16.5	87.0	25.5	97.5	71.5
S.D. (P = 0.05)	6.54	9.88	9.94	9.09	2.78	6.98

2. *At equivalent parts by weight.*

In this experiment emergence was not observed until 14 days after planting, the final count being made on the 21st day. The results are recorded in Table II.

The percentage emergence in the non-sterile soil was markedly less in all treatments than that in the sterile soil. This appreciable reduction in germination is probably due to the low temperatures prevailing at the time, which increased the pre-emergence period from approximately 7 to 14 days, and so provided a greater chance of the peas being attacked by "damping-off" fungi.

TABLE II.

VAR. SURPRISE: PERCENTAGE EMERGENCE IN STERILE AND NON-STERILE SOIL.

Treatment and Sample No.				Rate of application. % by wt.	% Emergence.	
					Sterile soil.	Non-sterile soil.
Copper sebacate	A ₁	..	..	0.5	89	63
	A ₂	..	..	0.25	93	63
	A ₃	..	..	0.125	97	49
Copper phosphate	B ₁	..	..	0.5	92	69
	B ₂	..	..	0.25	89	67
	B ₃	..	..	0.125	97	53
Cuprous oxide (Red)	C ₁	..	..	0.5	90	68
	C ₂	..	..	0.25	85	60
	C ₃	..	..	0.125	95	58
Cuprous oxide (Yellow)	D ₁	..	..	0.5	94	83
	D ₂	..	..	0.25	88	74
	D ₃	..	..	0.125	92	75
Control				—	89	21

The adherence figures are given in Table III.

TABLE III.

VAR. SURPRISE: ADHERENCE OF 4 COPPER COMPOUNDS APPLIED AT EQUIVALENT PARTS BY WEIGHT.

Treatment and Sample No. (80 gm. peas each).				Rate of application. % by wt.	Percentage adherence.	Mean % adherence.
Copper sebacate	A ₁	..	..	0.5	59.80	60.66
	A ₂	..	..	0.25	59.61	
	A ₃	..	..	0.125	62.56	
Copper phosphate	B ₁	..	..	0.5	77.31	78.64
	B ₂	..	..	0.25	84.61	
	B ₃	..	..	0.125	73.99	
Cuprous oxide (Red)	C ₁	..	..	0.5	93.44	94.10
	C ₂	..	..	0.25	93.89	
	C ₃	..	..	0.125	94.97	
Cuprous oxide (Yellow)	D ₁	..	..	0.5	95.98	96.55
	D ₂	..	..	0.25	96.05	
	D ₃	..	..	0.125	97.61	

The average percentage germination in sterile and non-sterile soil for each compound, together with the mean weight of copper adhering to the seeds, is given in Table IV.

TABLE IV.

Treatment.				Average % Germination.		Mean weight of copper adhering. gm. Cu. per 100 gm. seed.
				Sterile Soil.	Non-sterile Soil.	
Cu sebacate	..	..	..	93.0	58.3	0.042
Cu phosphate	..	..	..	92.7	63.0	0.104
Cu ₂ O (Red)	..	..	..	90.0	62.0	0.235
Cu ₂ O (Yellow)	..	..	..	91.3	77.3	0.240
Control	..	..	..	89.0	21.0	—
S.D. (P = 0.05)	..	..	..	5.39	9.72	—

Discussion.

(a) At Equivalent Copper Concentrations.

(i) Copper Damage.

The varieties "Surprise" and "Foremost" showed no copper damage.

but with "Eclipse" significant damage was caused by copper sulphate monohydrate and copper phosphate. The results agree with the findings of Croxall and Ogilvie (1) on the resistance of these varieties to copper dressings.

In four cases with "Eclipse," viz. the mucate, adipate, phosphate, and sulphate treatments, higher germination figures were obtained in the non-sterile than in the sterile soils. This anomaly can only be due to the different amounts of water added to the boxes, and illustrates the fact that copper damage can be more severe in dry soils.

(ii) *Control of "Damping-off."*

That conditions were suitable for "damping-off" is well illustrated by the results in Table I. The germination of the untreated peas in non-sterile soil was significantly lower than that of all the treated peas. An exception was copper thiocyanate, which throughout gave no control of the disease, a result expected because of the high degree of stability and the known poor fungicidal performance of this compound (4). Red cuprous oxide in this experiment, gave significantly less control with two varieties than that given by the mucate, sebacate, succinate and phosphate. These four substances all gave excellent protection. Copper mucate and sebacate were approximately equal in efficiency although the sebacate was superior with the variety "Foremost." Martin *et al* (4) found both these compounds to possess high fungicidal values, copper sebacate being significantly better than Bordeaux mixture.

(b) *At Equivalent Parts by Weight.*

A comparison of the performance of the four compounds used was complicated by their marked differences in adherence, but this was to some extent overcome by a direct estimation of this property. The sebacate, although finely divided, formed a tenacious deposit on the walls of the glass vessels used for treating the seeds, an effect probably associated with differences in electro-static charge. Attempts are now being made to eliminate this disadvantage and to improve the adherence of the sebacate to peas.

(i) *Copper Damage.*

No evidence of copper damage was obtained in this experiment with any treatment.

(ii) *Control of "Damping-off."*

"Damping-off" which was severe with the untreated seeds was controlled in all four treatments, yellow cuprous oxide being the most effective. There was, however, no significant difference in control between the sebacate, phosphate and red cuprous oxide in spite of the wide differences in the amount of adherent copper which were roughly in the ratio 1 : 2 : 5 (Table IV). It would seem therefore that the smaller quantity of copper present on the seed treated with sebacate is as effective as the larger quantities present on those treated with phosphate and cuprous oxide, an indication of the better protection afforded by the sebacate. The results given in Table II for the sebacate and phosphate show that the degree of control is similar for applications at 0.5 and 0.25% but is less at 0.125%. It would appear, therefore, that with these substances 0.25% by weight of the compound is the minimum rate of application to ensure adequate control.

Summary.

1. A number of pure copper compounds have been compared at equivalent copper concentrations as protectants for the control of "damping-off," using three varieties of pea seeds. A smaller number have been tested at equivalent weights of compound with one pea variety.*

2. Copper damage occurred in one experiment only, and was caused by the copper sulphate monohydrate and copper phosphate treatments.

3. The proprietary red cuprous oxide used was inferior to several of the other compounds tested. Of these, copper sebacate was consistently good, the results suggesting that this derivative merits further examination.

Acknowledgment.

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EXPERIMENTS WITH PROTECTANT SEED DRESSINGS, 1940-42.

By H. E. CROXALL and L. OGILVIE.

The experiments described in this paper form a continuation of the results published in 1939. An attempt has been made to obtain further information on the relative efficiency and optimum rates of application of various dry seed dressings. Most of the experiments were made with pea seeds, but some work was carried out with small seeds as, owing to the shortage and increased cost of these seeds, it was thought advisable to examine the possibility of obtaining increased emergence by the use of seed dressings.

I. EXPERIMENTS WITH PEA SEEDS.

Experimental Methods.

The seed was treated by the methods described in a previous paper (9) except that the dosages used were as stated below. For sowings in boxes the procedure adopted was that described in the same paper. All experiments were laid out in randomised blocks, and the results were analysed statistically. In the tables treatments which gave results differing significantly from the controls are shown by + or - at 5% pt. and ++ or -- at 1% pt.

A. Greenhouse Experiments.

Experiment 1.

Seeds of the round-seeded variety Foremost and the wrinkled-seeded variety The Lincoln were treated with each of the following dressings:—red cuprous oxide, yellow cuprous oxide and a proprietary organo-mercury dressing, M 1. Each dressing was applied at three different rates, 0.125%, 0.25% and 0.5% by weight of the seed. In order to determine whether injury would result from any of these treatments sowings of treated and untreated seed were made in steam sterilised soil. The boxes were kept dry in order that the conditions should be favourable for damage. There were four replicates of each treatment and the untreated control. Similar sowings were made in boxes of garden soil watered immediately after sowing in order to compare the protection afforded against pre-emergence damping-off. The results are given in Table I.

TABLE I.
PERCENTAGE EMERGENCE OF TREATED AND UNTREATED PEA SEED.

Treatment.	Dosage.	Variety Foremost.		Variety The Lincoln.	
		Sterile Soil. % Emergence.	Garden Soil. % Emergence.	Sterile Soil. % Emergence.	Garden Soil. % Emergence.
Control	0	57	46	78	61
Red Cuprous Oxide . .	0.125%	53	48	77	73 +
" " " " "	0.25%	48 -	46	72	71 +
" " " " "	0.5%	53	49	75	75 ++
Yellow Cuprous Oxide	0.125%	48 -	36	76	69
" " " " "	0.25%	46 -	46	76	76 ++
" " " " "	0.5%	41 - -	40	69 -	74 +
M1 . .	0.125%	55	49	80	70 +
" . .	0.25%	57	52	81	71 +
" . .	0.5%	45 - -	46	76	73 +
S.E.		2.88	5.32	2.83	3.01
Diff. required for significance					
5% pt.		8.36	15.34	8.22	8.90
" " " " " 1% pt.		11.30	20.86	11.10	12.04

With the variety Foremost sown in sterile soil the emergence of seed treated with red cuprous oxide at the 0.25% rate was significantly below that of the untreated seed, but too much emphasis cannot be placed on this as no depression of emergence was produced by the application of 0.5% of dressing. The emergence of seed treated with yellow cuprous oxide at all three concentrations was significantly lower than that of the control, the difference with 0.5% dosage being significant at the 1% pt. With the mercurial dressing a lower emergence was obtained only with seed treated at the highest rate of application and again the difference was significant at the 1% pt. In the garden soil no significant differences were obtained.

The variety The Lincoln gave rather different results. In sterile soil the emergence was depressed only by yellow cuprous oxide applied at the 0.5% rate, and the difference was only just significant at the 5% pt. In the sowings in garden soil all treatments except yellow cuprous oxide at the 0.125% dosage gave an emergence significantly greater than the untreated seed. The difference with red cuprous oxide applied at 0.5% by weight and yellow cuprous oxide applied at 0.25% was significant at the 1% pt.

These results are in agreement with those of other workers (6, 8) that wrinkled-seeded varieties tend to be more susceptible to pre-emergence damping-off. The round-seeded variety Foremost appeared to be more easily injured than The Lincoln.

Experiment 2.

In order to obtain more information on the relative efficiency of the different treatments further sowings of The Lincoln were made in boxes of garden soil. In one test the treatments were as in the previous sowings, while in a second test a different proprietary organo-mercury dressing, M2,

was substituted for M1. There were eight replicates of each treatment. The results are given in Table II.

TABLE II.

PERCENTAGE EMERGENCE OF TREATED AND UNTREATED PEA SEED, VARIETY, THE LINCOLN.

Treatment.	Dosage.	Test 1. % Emergence.	Test 2. % Emergence.
Control	—	41	32
Red Cuprous Oxide ..	0.125%	75 ++	72 ++
" " " ..	0.25%	80 ++	73 ++
" " " ..	0.5%	77 ++	81 ++
Yellow Cuprous Oxide ..	0.125%	82 ++	82 ++
" " " ..	0.25%	89 ++	91 ++
" " " ..	0.5%	91 ++	89 ++
M1 ..	0.125%	50 +	—
M1 ..	0.25%	67 ++	—
M1 ..	0.5%	76 ++	—
M2 ..	0.125%	—	42 +
M2 ..	0.25%	—	50 ++
M2 ..	0.5%	—	45 ++
S.E.		2.58	3.02
Diff. required for significance at 5% pt. ..		7.3	8.6
" " " " " 1% pt. ..		9.6	11.4

In both tests all treatments gave an emergence significantly greater than that of untreated seed. The difference was significant at the 1% point except where the lowest dosage of the mercurials was used.

In Test 1 variation of the rate of application of red cuprous oxide did not cause any significant difference in the emergence of the seed. Pre-emergence damping-off was more severe in the second test, and here treatment at the highest rate of application gave an emergence just significantly greater than when the lowest, 0.125%, dosage was used.

Yellow cuprous oxide, in both trials, applied at 0.5% and 0.25% gave an emergence just significantly greater than the emergence when the 0.125% rate was used.

In Test 1 the emergence of seed treated with the organo-mercury preparation M1 at 0.5% dosage was significantly greater than the emergence obtained by applying the dressing at 0.25%, and this rate gave an emergence significantly greater than when the 0.125% was used. In the second test with the dressing M2 the highest emergence was given by seeds treated at the 0.25% rate, but the differences were not statistically significant.

Experiment 3.

In a further experiment red and yellow cuprous oxides and several organo-mercury preparations, M1, M2, M2A, M3, M3A, M4A, and M5 were used. M2A and M3A were samples of M2 and M3 respectively which had been in store for two years. All dressings except yellow cuprous oxide were applied at 0.25% by weight of the seed. The yellow cuprous oxide was used at a

dosage of 0.125%, as in the previous experiments this rate appeared to give adequate protection to the seeds while the higher rates were likely to be injurious under dry conditions. Thus the two cuprous oxides were applied at the rates likely to give the maximum protection compatible with the least risk of injury. There were eight replicates of each treatment and the control. The final percentage emergence is given in Table III.

TABLE III.

PERCENTAGE EMERGENCE OF TREATED AND UNTREATED PEA SEED. VARIETY, THE LINCOLN.

Treatment.						Dosage.	% Emergence.
Control	..	..	..	..	..	—	19
Red Cuprous Oxide	..	..	..	..	..	0.25%	68 ++
Yellow Cuprous Oxide	..	..	..	..	..	0.125%	78 ++
M1	..	..	..	..	..	0.25%	49 ++
M2	..	..	..	..	..	0.25%	39 ++
M2A	..	..	..	..	..	0.25%	35 ++
M3	..	..	..	..	..	0.25%	44 ++
M3A	..	..	..	..	..	0.25%	40 ++
M4A	..	..	..	..	..	0.25%	16
M5	..	..	..	..	..	0.25%	37 ++
S.E.	..	..	..	..	..	..	2.78
Differences required for significance						5% pt.	7.8
"						1% pt.	10.4

All treatments except M4A gave an emergence significantly greater, at 1% point, than that of untreated seed. The emergence of seed treated with yellow cuprous oxide at 0.125% dosage was significantly greater, at the 5% point, than when the red oxide was used at 0.25% dosage. Treatment with either cuprous oxide dressing gave a result significantly better than was obtained with any of the organo-mercury preparations. Apart from M4A, an old sample which was ineffective, the organo-mercury dressings gave fairly uniform results, although M1 was significantly better than M2A, M3A and M5. The seed treated with the old samples M2A and M3A gave an emergence slightly lower than that treated with the corresponding new samples, but the difference was not significant.

Experiment 4.

Further trials were made to compare the efficiency of different cuprous oxides and to ascertain the effect of incorporating graphite with cuprous oxide before use. Yellow cuprous oxide, a bright red cuprous oxide, a dark red cuprous oxide and also a mixture, prepared by the manufacturer, of dark red cuprous oxide and graphite in equal proportions, were used. In order to have the same quantity of fungicide present, this mixture was used at twice the rate of application of the red oxides. As in the previous experiment the yellow cuprous oxide was applied at 0.125% dosage in order to reduce the risk of injury to the seed. The results are given in Table IV.

TABLE IV.

PERCENTAGE EMERGENCE OF TREATED AND UNTREATED PEA SEED. VARIETY, THE LINCOLN.

Treatment.	Dosage.	% Emergence.
Control	—	37
Yellow Cuprous Oxide	0.125%	90 ++
Bright Red Cuprous Oxide	0.25%	84 ++
Dark Red Cuprous Oxide	0.25%	91 ++
Dark Red Cuprous Oxide + Graphite	0.5%	91 ++
S.E.		5.51
Difference required for significance at 5% pt.		10.29
" " " " " 1% pt.		14.64

All the dressings gave an emergence significantly greater at the 1% point than that of the untreated seed, but no dressing was significantly better than the others. The yellow oxide, applied at 0.125% dosage, was as effective as the red oxides applied at the 0.25% rate. The difference in colour of the two red oxides was not accompanied by any difference in performance. This fact is contrary to the specification laid down by Heuberger and Horsfall (5), but agrees with the results of Anderson and his co-workers (1). Another important point shown by this experiment was that incorporation of graphite with cuprous oxide before use did not impair the efficiency of the dressing. Arnold and Horsfall (2) found that a lubricant is essential if cuprous oxide treated seed is sown by a drill, and if the mixture of dressing and graphite is prepared by the manufacturers it will prevent damage being caused by growers omitting to add or adding insufficient graphite when dressing the seed.

In a second experiment seed of the variety Onward was treated with bright red cuprous oxide, dark red cuprous oxide, a mixture of 75% cuprous oxide and 25% graphite and three organo-mercury dressings M1, M1A, and M2. The 75 : 25 mixture of cuprous oxide and graphite used in this combination contained the requisite amount of lubricant, and it was applied at a dosage of 0.33% so that the amount of cuprous oxide present should be the same as when the pure cuprous oxide was used. M1 and M1A were the same proprietary dressing except that M1A had become slightly damp. The results are given in Table V.

TABLE V.

PERCENTAGE EMERGENCE OF TREATED AND UNTREATED PEA SEED. VARIETY, ONWARD.

Treatment.	Dosage.	% Emergence.
Control	—	63
Bright Red Cuprous Oxide	0.25%	79 ++
Dark Red Cuprous Oxide	0.25%	84 ++
Dark Red Cuprous Oxide + 25% Graphite	0.33%	87 ++
M1	0.25%	84 ++
M1A	0.25%	70 +
M2	0.25%	81 ++
S.E.		2.19
Difference required for significance at 5% pt.		6.6
" " " " " 1% pt.		8.9

All treatments gave a greater emergence than the control, the difference being significant at the 5% point for treatment 1A, and at the 1% point for all other treatments. There was little difference between the results from the different cuprous oxide treatments, the dark red sample being quite as effective as the bright red, and the prior admixture of graphite with the cuprous oxide did not impair the efficiency of the dressing. Apart from 1A the mercurial dressings gave results equally as good as those obtained by the cuprous oxide dressings. The lower germination with 1A was probably due to the damp dressing not giving an even cover or being present in excess on some seeds.

Experiment 5.

In order to obtain conditions closer to those in the field further sowings were made in the border of a cold greenhouse. A new American proprietary dressing, Sperguson, containing tetrachloro-para-benzoquinone, was used in this series of trials in addition to the dressings already mentioned. M1B and M2B were new samples of the dressings M1 and M2 respectively. The wrinkled seeded varieties The Lincoln, Thomas Laxton and Onward and the round-seeded variety Foremost were sown in this series of experiments. There were ten replicates of each treatment with the variety Onward, and five replicates per treatment with each of the other varieties. The results are given in Table VI.

TABLE VI.
PERCENTAGE EMERGENCE OF TREATED AND UNTREATED PEA SEEDS.

Treatment.	Dosage.	% Emergence.			
		The Lincoln.	Thomas Laxton.	Onward.	Foremost.
Control	—	47	55	70	90
Yellow Cuprous Oxide ..	0.125%	54	57	—	92
Bright Red " "	0.25%	58 +	66	74	97 +
Dark Red " "	0.25%	65 ++	—	—	—
M1	0.25%	67 ++	56	—	92
M1B	0.25%	—	59	—	96 +
M2	0.25%	54	—	68	—
M2B	0.25%	—	—	66	—
Sperguson	0.25%	60 ++	58	76	93
S.E.	..	3.33	4.36	2.36	1.83
Diff. required for sig. at 5% pt.	5% pt.	9.5	12.9	6.8	5.44
" " " " " 1% pt.	1% pt.	12.7		8.2	

Treatment of the seed of The Lincoln with the two cuprous oxides, the organo-mercury dressing M1 and Sperguson resulted in an emergence significantly greater than that of untreated seed. In the sowings of Thomas Laxton and Onward no significant differences were obtained. The amount of pre-emergence damping-off was small in the sowing of Foremost, but increases in stand significant at the 5% point were obtained with seed treated with red cuprous oxide and the mercurial dressing M1B.

Experiment 6.

In order to determine whether seed dressings would affect the emergence

of seed infected with *Ascochyta Pisi* samples of infected seed of two varieties were treated with various dressings. Four replicates of each treatment and untreated seed were sown in boxes of steam-sterilised soil. The results are given in Table VII.

TABLE VII.
PERCENTAGE EMERGENCE OF TREATED AND UNTREATED PEA SEED INFECTED WITH
ASCOCHYTA PISI.

Treatment.	Dosage.	% Emergence.	
		Pioneer.	Autocrat.
Control	—	14	85.5
Red Cuprous Oxide ..	0.25%	16	—
M1	0.25%	14	—
M2	0.25%	21	85.5
M2B	0.25%	19	—
M3	0.25%	16	—
Spargon	0.25%	25 +	91.0 +
S.E.		2.4	4.4
Difference required for significance at 5% pt.		8.3	15.3

The variety Pioneer was severely infected and in many of the seeds examined the fungus had penetrated the testa. The infection was less severe in the variety Autocrat. Spargon was the only dressing which gave an emergence significantly greater than that of untreated seed.

Isolation and Inoculation Experiments.

In some experiments additional boxes of untreated seed of the variety The Lincoln were sown. Seeds were removed at daily intervals, starting three days after sowing, and isolations made by the method used by Baylis (3). During the first six days after sowing, species of *Pythium*, particularly *Pythium ultimum*, were isolated almost exclusively. In later isolations species of *Mucor* and *Thamnidium* predominated and *Rhizoctonia Solani* was occasionally present. In order to test the pathogenicity of the fungi isolated they were grown for fourteen days on a corn meal medium which was used to inoculate steam-sterilised soil. The mean percentage emergence of peas, variety The Lincoln, grown in this inoculated soil is given in Table VIII.

The inoculum was mixed with the soil at the rate of about 5% by weight of the soil.

TABLE VIII.
PERCENTAGE EMERGENCE OF PEA SEED SOWN IN ARTIFICIALLY CONTAMINATED SOIL.

Fungus added to Soil.	% Emergence.
Control (Sterile soil)	83
<i>Pythium ultimum</i>	58
<i>Pythium sp.</i>	62
<i>Rhizoctonia Solani</i>	52
<i>Mucor sp.</i>	72
<i>Thamnidium sp.</i>	78

These results indicated that species of *Pythium* are important causes of pre-emergence damping-off. *Rhizoctonia Solani* is also capable of causing decay of germinating pea seeds, but is probably not such an important factor, as it was isolated on relatively few occasions.

B. Field Experiments.

Owing to shortage of labour it has been difficult to carry out successful large scale field trials. In a number of cases trials were begun but yielded no information owing to attacks by pests. In 1942 three field trials were laid down in commercial farms in Somerset. It was possible to include only four replicates of two treatments and untreated controls at each centre. An estimate of the stand was obtained by counting numbers of seedlings in twenty one-yard lengths of row taken at random in each plot. The results are given in Table IX.

TABLE IX.

PERCENTAGE EMERGENCE IN FIELD TRIALS OF TREATED AND UNTREATED PEA SEED. VARIETY, ONWARD.

Treatment.	Dosage.	(1)		(2)		(3)	
		No. of plants per yd. of drill.	Emergence as % of Control.	No. of plants per yd. of drill.	Emergence as % of Control.	No. of plants per yd. of drill.	Emergence as % of Control.
Control	—	13.70	100	12.15	100	14.80	100
Red Cuprous Oxide + Graphite	0.25%	—	—	15.0	123.4++	16.1	108.8+
Mercurial 1	0.25%	16.35	119.3++	13.65	112.3	14.65	99.0
Mercurial 2	0.25%	16.55	120.8++	—	—	—	—
S.E.		0.56	4.04	0.73	5.97	0.41	2.77
Diff. required for sig. 5% pt.		1.58	11.50	2.05	16.87	1.16	7.84
" " " " 1% pt.		2.08	15.00	2.74	22.51	1.54	10.44

In trial (1) treatment with both mercurial dressings resulted in an increase in stand significant at the 1% point.

In trials (2) and (3) the seed treated with cuprous oxide and graphite gave a higher emergence than the untreated seed and the increase was statistically significant. Treatment with the mercurials did not result in a significant increase in stand in these two trials.

It was not possible to record yields in these trials.

II. EXPERIMENTS WITH MISCELLANEOUS SMALL SEEDS.

Tomato.

Seeds of the tomato variety Early Market were treated with red and yellow cuprous oxides respectively, each applied at four different rates. Six replicates of each treatment were sown in boxes of garden soil, the seed being covered by about $\frac{1}{8}$ " of soil. The final % emergences are given in Table X.

TABLE X.
PERCENTAGE EMERGENCE OF TREATED AND UNTREATED TOMATO SEED.
VARIETY, EARLY MARKET.

Treatment.	Dosage.	% Emergence.
Control	—	55.8
Red Cuprous Oxide	0.25%	62.0
" " " " " " " " " " " "	0.5%	64.4
" " " " " " " " " " " "	1.0%	59.2
" " " " " " " " " " " "	2.0%	75.2 +
Yellow " " " " " " " " " " " "	0.25%	79.2 +
" " " " " " " " " " " "	0.5%	80.0 +
" " " " " " " " " " " "	1.0%	72.0 +
" " " " " " " " " " " "	2.0%	64.0
S.E.		5.17
Difference required for significance at 5% pt.		15.0

Treatment with red cuprous oxide at 2% and yellow cuprous oxide at 0.25, 0.5 and 1.0% all resulted in an emergence significantly greater at 5% point than that of the untreated seed. Red cuprous oxide was ineffective at the lower rates of application. The yellow oxide applied at 0.25% and 0.5% gave an emergence significantly greater than when it was used at 2.0%, suggesting that the dressing was injurious at the highest dosage.

In a second experiment a greater variety of dressings was used. There were six replicates of each treatment, the details being given in Table XI.

TABLE XI.
PERCENTAGE EMERGENCE OF TREATED AND UNTREATED TOMATO SEED.
VARIETY, EARLY MARKET.

Treatment.	Dosage.	% Emergence.
Control	—	64.4
Red Cuprous Oxide	2.0%	72.0
Yellow Cuprous Oxide	1.0%	69.0
M1	1.0%	74.2 +
M2	2.0%	71.4
Zinc Oxide + sticker	2.0%	63.4
Zinc Oxide + Zinc Carbonate	2.0%	62.0
Sperguson	2.0%	72.4
S.E.		2.84
Difference required for significance at 5% pt.		8.14
" " " " " " " " " " " " 1% pt.		10.32

Dressing with mercurial M1 alone caused a significantly higher emergence over that of untreated seed. This is a surprising result, as previous experiments had indicated that mercurials were very liable to damage tomato seed.

Onion.

Onion seed, variety Ailsa Craig, was treated with a similar range of dressings and sown in boxes in a cold house. The results are given in Table XII.

TABLE XII.
PERCENTAGE EMERGENCE OF TREATED AND UNTREATED ONION SEED.
VARIETY, AILSA CRAIG.

Treatment.	Dosage.	% Emergence.
Control	1.0%	66.25
Red Cuprous Oxide	"	69.0
Yellow Cuprous Oxide	"	73.75
M1	"	70.0
M2	"	74.0
Zinc Oxide	"	74.25
S.E.		4.84
Difference required for significance 5% pt.		14.58

There were no significant differences in emergence caused by any treatments.

Cabbage.

Seed of cabbage was treated with various dressings as shown in Table XIII. The seed was sown outside in drills $\frac{1}{2}$ " deep.

TABLE XIII.
PERCENTAGE EMERGENCE OF TREATED AND UNTREATED CABBAGE SEED.

Treatment.	Dosage.	% Emergence.
Control	2%	54
Red Cuprous Oxide	"	52.3
Yellow Cuprous Oxide	"	41.6
M1	"	58.3
M1A	"	50.6
M2	"	64.0
M2A	"	63.6
Zinc Oxide (1)	"	49.3
Zinc Oxide (2)	"	69.3
Zinc Oxide + Sticker	"	69.3
Zinc Hydroxide	"	58
Zinc Carbonate	"	66.3
Zinc Oxide + Zinc Hydroxide	"	51
Zinc Oxide + Zinc Carbonate	"	70
Spergon	"	55
S.E.		12.16
Difference required for significance at 5% pt.		35.2

There were no significant differences resulting from the seed treatments, the standard error being very high in this experiment.

A sowing of untreated savoy seed and seed treated with Spergon was also made in a seed bed, but again no significant differences were obtained.

Similarly flax seed treated with a proprietary dressing did not show any increase in germination over untreated seed. No seed-borne diseases were present in the crop, so that no information was obtained on the control of these diseases by the seed dressing.

General Discussion.

In greenhouse trials the experiments indicated that when the conditions were favourable for pre-emergence damping-off increases in emergence could be obtained by treatment of pea seed with red and yellow cuprous oxides, proprietary organo-mercury dressings and Spergon respectively. When damping-off was severe (Tables II and III) the cuprous oxide dressings were somewhat more effective than the organo-mercury dressings applied at the same dosage rate. The yellow oxide was rather more effective than the red oxides used at the same rate. There was no significant difference between the bright red and dark red cuprous oxides applied at the same rate, nor was the efficiency impaired by addition of graphite as a lubricant.

On the other hand the cuprous oxides, particularly the yellow cuprous oxide, even applied at only 0.125% of the weight of seed, appeared more likely to cause injury to pea seed than the mercurial dressings, especially to the round seeded variety Foremost under dry soil conditions. A reduced germination occurred only once with a mercurial dressing, and this when it was applied at 0.5% dosage, twice the rate recommended by the makers. Owing to the possibility of injury it would thus be unwise to recommend yellow cuprous oxide as a seed dressing for peas. The red oxides if applied at not more than 0.25% by weight of cuprous oxide are not likely to cause damage unless the soil is abnormally dry. All the organo-mercury dressings were reasonably effective except one dressing, M4A, in one experiment (Table III), and this was an old sample. If applied at the correct dosage it is improbable that they would cause injury. In the few experiments in which Spergon was used it gave promising results, and this dressing undoubtedly merits further trial.

The two experiments with *Ascochyta* infected seed are not sufficient to draw any definite conclusions, but here again Spergon gave promising results.

From the isolations made species of *Pythium* seemed to be mainly responsible for damping-off. This is in agreement with the results of other workers (3, 4, 7). In addition an isolation of *Rhizoctonia Solani* was found to be pathogenic, as was also shown by Jones and Linford (7). C. J. Hickman has also found this fungus in the field in Worcestershire on peas which had failed to germinate.

Further work is needed to test these dressings in the field and to determine their effect on crop yields. Information is also needed on the possibility of reducing the seeding rate of peas by sowing dressed seed. Under present conditions of scarcity and high price of pea seeds important savings might be achieved in this way.

Apart from tomatoes no significant increases in stand have been obtained by treating small seeds. In the case of tomato, seed treatment can only be regarded as a substitute for sowing in sterile soil when this is unavailable. Although no improvement was obtained by dressing Brassica and onion seeds, the number of experiments was small, so that the possibility of seed dressings being used with advantage in these seeds cannot be ruled out.

Summary.

1. Greenhouse and field experiments showed that when untreated pea seed was subject to pre-emergence damping-off increased emergence was obtained by treating the seed with cuprous oxide, proprietary organo-mercury dressings and a proprietary product, Spergon, respectively.

2. In dry soil round-seeded peas treated with yellow cuprous oxide, red cuprous oxide and an overdose of a proprietary organo-mercury dressing gave an emergence lower than that of untreated seed.

3. Isolations from pea seeds sown in garden soil indicated that *Pythium* spp. were the chief causes for rotting of pea seeds before germination. *Rhizoctonia Solani* was also shown to be pathogenic.

4. Some improvement in the germination of tomato seed was obtained by seed treatment, but onions, cabbage, savoy and flax did not benefit from seed dressings in the small number of experiments made.

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A SMALL ACID SPRAY OUTFIT FOR SPRAYING ONION BEDS.

By H. G. H. KEARNS.

Wartime conditions have rendered it necessary to increase considerably the acreage of bulb onions grown in this country. The successful culture of this crop depends largely on efficient weeding at the early stages of growth, and this cannot be achieved under existing conditions by hand labour. The application of sulphuric acid (1, 2, 3) for the control of weeds is the only way of reducing the labour of hand weeding to reasonable proportions. The majority of the onion crops in the West of England, where the weed problem is particularly acute, are grown in small acreages. The small amount of acid spraying carried out has been done by means of copper, brass, tinned and lead-coated knapsack sprayers. This type of sprayer is not well suited for acid spraying as the application is slow, tedious and most unpleasant for the operator, and frequently results in extensive damage to clothing.

It became apparent that there was a need for a small, wheeled manual sprayer which would encourage the more extensive use of the acid. A small proprietary make of lime washer has been modified to suit the special conditions.

The outfit consists of an acid-proofed tank fitted with handles and an axle with wheels, a manually operated pump and 30' of $\frac{1}{4}$ " bore delivery hose fitted to a three-nozzle spray broom.

The sprayer is wheeled into the onion bed and placed in a convenient position. One operator works the pump and a second applies the diluted acid. It is possible, if desired, to use two spray brooms.

The pump, in addition to pumping diluted acid to the spray brooms, will suck concentrated acid from carboys and deliver it to a separate mixing vessel. This is a great advantage, as it avoids unnecessary handling of acid and thereby reduces the risk of accidents.

Description of the Outfit.

The tank, 18" x 14" x 14" of 14 G. (0.078") sheet iron, is welded at all the seams. One end is left open and a ledge $\frac{3}{4}$ " wide and $\frac{3}{4}$ " from the top is welded to the sides. Each ledge is drilled at suitable positions and the holes threaded to take $\frac{1}{4}$ " diameter brass set screws for holding down a tank lid. $1\frac{1}{2}$ " from the bottom of the tank and 4" from one side an axle tube of 29/32" bore x 16" long and of $\frac{1}{8}$ " wall thickness is welded through the tank, so that it is parallel to one side and protrudes equally on the two sides. A handle is welded on each side of the tank at the open end at right angles to the axle tube. Each handle consists of $1\frac{1}{4}$ " x $\frac{1}{4}$ " iron and extends 20" beyond the tank and is cross-braced. At the bottom of the tank midway between the handles a rest 7" x 2" x $\frac{1}{4}$ " is welded 6" below the bottom of the tank. A support base for the pump is welded to the inside of the bottom of the tank. The whole assembly, after careful cleaning with deoxidene to remove every trace of rust, is heavily coated with lead-tin solder, consisting of 3 parts by weight of lead

and 1 part tin, which has sufficient resistance to sulphuric acid. As a final precautionary measure against acid corrosion the tank is coated on all surfaces with a chromate primer and finished with an acid resistant bituminous paint.

An axle rod, $\frac{7}{8}$ " round x 28" long, is fitted through the axle tube and located by grub screws fitted in the protruding portions of the tube. The axle is drilled at the ends to permit of alternative track widths of the wheels. The wheels are 16" diameter x 2" tread, and are kept in position on the axle by passing large split pins through the holes in the axle.

All metal parts not tinned are painted with bitumen.

The cover lid of the tank is made in two equal halves of $\frac{3}{4}$ " ash and rests freely on the iron ledge in the top of the tank. The wood is held in position by brass wing nuts fitted to brass set screws. The capacity of the tank is approximately 12 gallons.

The pump is a proprietary article modified to suit the special conditions for the use of acid. It is made of heavy gauge brass tube and cast brass and heavily tinned throughout, though the brass without the tinning is satisfactory provided the pump is carefully washed out after use. The plunger of the pump is single acting, of 2" bore and 3" stroke, and its capacity is 10 pints per minute at 50 lb. per square inch at 80 strokes. The plunger washers are made of moulded and acid-resistant rubber. The suction and delivery valves are of bronze and fitted to quickly replaceable and reversible brass seats.

The inlet valve situated at the bottom of the pump is fitted with an elbow threaded $\frac{3}{4}$ " B.S.P. male. At the top of the large air vessel a two-way branch is fitted with each branch $\frac{3}{4}$ " B.S.P. male thread. The pump is fitted into the tank by means of a split clamp ring bracket on the air cylinder which is attached by bolts to one half of the wooden cover lid. The bottom of the pump has a casting which fits into the support base inside the tank. This assembly of the pump makes a secure fitting well able to withstand the leverage on the pump handle.

The spray broom consists of a light brass lance $3\frac{1}{2}$ ' long, fitted with a cock for a $\frac{3}{4}$ " B.S.P. hose connection. The broomhead is 22" wide and fitted with 3 light-weight spray nozzles with 4/64" apertures. The nozzles are fitted with removable swirl plates. The broom is well balanced and easy to handle. High-pressure rubber hose of $\frac{1}{4}$ " bore is fitted, this small size of hose obviating any damage when dragged over the onions. Two 7' lengths of hose of $\frac{1}{2}$ " bore are also provided for the removal of concentrated acid from carboys.

All fittings are brass, tinned iron or tinned brass. The price of the outfit at present is approximately £20.

Strength of Acid for Use on Onions.

Commercial sulphuric acid, known as brown oil of vitriol, contains approximately 75% of acid. It reacts violently with water with an evolution of heat, and for this reason *on no account* should water be added to the acid, as a serious accident may result. The acid should be added to the water, making sure that the volume of water is not less than five times the volume of the acid. As the acid is added to the water, the mixture must be stirred in order to prevent the heavy acid settling at the bottom of the container and reacting violently with the water.

Two strengths of acid (B.O.V.) are generally used : 13½% for application to the surface of the ground before the onion seedlings have emerged through the soil, and 10% for use when the seedlings have passed the crooked stage and are about 3" high. It should be noted that onion seedlings that are just emerging through the soil are easily killed by the acid.

Method of Diluting the Acid.

The two short lengths of ½" bore hose are attached to the pump. One length is fitted to one branch of the two-way outlet branch at the top of the pump barrel and the other to the screwed upturned elbow fitted to the inlet valve of the pump. The latter is fitted to the bottom of the pump inside the tank and the hose can be attached to it by inserting an arm through the hinged lid at the top of the tank. Care must be taken that washers are inside the caps of the hose couplings and the blank cap of the two-way branch and all joints must be screwed up tightly.

The suction hose, *i.e.*, the one fitted to the bottom of the pump, is placed into the acid in the carboy, and the ½" bore delivery hose, *i.e.* at the top of the pump, is placed inside a wooden tub of water. The tub, preferably of 40 gallons capacity, should have been filled with water up to a 40-gallon mark (indicated by a brass screw), and from it is removed either 5 gallons 3 pints or 4 gallons according to whether 13½ or 10% acid respectively is required. The pump lever is then operated at the rate of about 70-80 strokes per minute until the 40-gallons mark is reached. The water must be stirred as the acid enters the tub. The suction hose is then lifted from the acid level in the carboy, allowed to drain for a few seconds, then carefully placed into the tub of diluted acid. The pump lever is worked for about two minutes so that the concentrated acid in the pump is displaced by the diluted acid*.

Application of the Diluted Acid.

The 12-gallon tank of the outfit may be filled with about 10 gallons of diluted acid either by pumping it from the tub or more rapidly by means of an enamel or bitumen painted pail. In either case the acid should pass through the brass gauze filter tray, which procedure prevents any subsequent trouble from blocked nozzles.

The short length of ½" bore delivery hose fitted to the top of the pump is removed and replaced by the 30' of ¼" bore hose and broom. The suction hose is pushed well into the tank and the tank lid fitted into position. If preferred the suction hose can be removed and in this case the tank must be filled by means of an enamel pail.

The pump is operated to make sure that all the hose and broom joints are secure and then the outfit is moved into position on the onion bed. The spraying should be carried out in a methodical manner. With 30' of delivery hose an area of 12 yards by 15-16 yards can be sprayed with the outfit in a central position. The bed is best sprayed in strips 12 yards wide running in the direction of the onion rows, the outfit being pushed, straddled over two

* The displaced concentrated acid amounts to about 3 pints, and therefore this volume increases the concentration of the diluted acid in the tub slightly. If an accurate concentration is required it can be obtained by withdrawing the suction hose from the carboy when the level in the tub is three pints below the 40-gallon level mark.

rows, up the middle of each strip. The 3-nozzle broom covers a yard width of soil or three rows of onions. The sprayman should walk forward holding the broom in front of him with nozzles about 8 to 14 inches above the soil. Spraying must not be done when standing still, as serious damage may be caused to the onions by overspraying. Each area of 180 square yards requires 4-6 gallons of acid (i.e. 100-160 gallons per acre). The outfit is then moved along the rows for 15-16 yards and the next area sprayed and so on. When the strip is completed the outfit is moved to the middle of the next 12 yards width of strip.

If one broom fitted with 3 nozzles with $\frac{1}{64}$ " apertures is used, the pump should be operated at about 38-44 strokes per minute to give an output of 5 pints per minute. Two brooms would require 75-88 strokes per minute to deliver 10 pints per minute.

A bar type foot rest is fitted behind the wheels to keep the outfit steady when at rest. It is best to place a piece of wood, say 12" x 6", beneath it when the pump is operated to prevent sinking into the soil.

The acid should only be applied to dry plants, and it is important that 2-6 hours should elapse between the spraying and any rainfall to ensure satisfactory results. If a slight breeze is blowing the position of the outfit and sprayman should be adjusted to avoid spray drift.

If a large onion bed is sprayed tubs of water and carboys of acid should be placed in convenient positions to avoid unnecessary waste of time in filling up the outfit. Two operators using one broom and including all operations should be able to apply 100 gallons of diluted acid in seven hours.

Maintenance of the Outfit.

After use it is most important that the tank pump, hoses and brooms are first washed out with water, then soda water, then water. The soda water should be made by dissolving $\frac{1}{2}$ lb. of ordinary washing soda in 2 gallons of water, and is sufficient if pumped through the pump and hoses. If dilute acid is left in the outfit considerable damage will result.

The rubber bucket washers of the pump plunger tend to stick when not in use, and considerable up or down leverage may be necessary to move them. Once the plunger moves it works freely after a few strokes.

About twice a day all the moving parts above the lid of the tank, namely the yoke ends of the lever handle fitted on the pump barrel and the pin of the pump rod, should be lubricated with thin oil. The wheel bearings occasionally require a few drops of oil.

The brass wing nuts holding the wooden platform on to the top of the tank must be kept tight, and also the two screws of the clamp bracket holding the pump barrel to the wooden platform.

The pump and the wooden platform are readily removed from the tank by unscrewing the wing nuts. When the pump is replaced it is most important that the three legs on the base of the pump fit into the holes in the base plate fitted to the bottom of the tank.

If, after extensive use, the efficiency of the pump decreases it is most likely due to a worn inlet and/or outlet valves. Each of the valves consists of a bronze ball and a replaceable and reversible valve seat. The seat is

reversed and sometimes a new bronze ball must be fitted. The inlet valve is at the base of the plunger tube and the outlet valve at the base of the main pump tube (air cylinder), and both are accessible by removal of the cast brass base of the pump. The valve seat is held in position by the ball cage, which is unscrewed, the seat in the form of a disc is reversed and the cage replaced. The seat is fitted on top of a rubber washer which should be renewed if damaged or perished. During assembly of the pump it is important to note that the rubber gaskets of the basal casting are in good condition. The brass set screws must be screwed up firmly first and then the lock nuts.

The hoses are held on to the hose connections (the linings) by means of brass wire loops which require fitting by means of special pliers. If these are not available ordinary brass wire can be used to make a clip.

If the correct type of washers for the caps of the hose connections, the broom joints and the nozzles are not available, a temporary washer can be made out of string soaked in oil.

The spray nozzles fitted to the brooms occasionally become blocked. A thin wire pushed into the aperture may clear the obstruction, but usually it is necessary to remove the nozzle and screw out the swirl plate and clean out the slots as well as the aperture.

Protective Clothing and Safety Measures.

The concentrated acid attacks the skin causing almost instantaneous damage, and therefore it must be handled with extreme care. Both the concentrated and dilute forms cause the rapid corrosion of many metals and clothing. The dilute acid causes the skin to smart, but it does not cause any undue injury. Washing soda neutralises the acid and it is wise before the acid is handled to dissolve $\frac{1}{2}$ lb. of soda in a pail of 2 gallons of water. This solution is then immediately available for accidental contamination of person or clothing.

In view of the corrosive nature of the acid it is desirable to wear either old or some form of protective clothing. A boiler suit that has been previously dipped in soda water (1 lb. per 1 gallon water) and dried and then dipped again at the end of a day's spraying does not suffer undue damage. Light oilskin coats are reasonably satisfactory but very hot to wear. It is wise to wear eye shields, such as the cheap A.R.P. pattern, when diluting the acid. The sprayman and the pump operator should wear oilskin gloves and rubber Wellington knee boots. All clothing that comes into contact with the acid should be dipped or moistened with the soda solution.

Summary.

A small wheeled manually operated sprayer is described for the application of sulphuric acid as a means of destroying weeds on onion beds.

The outfit consists of a 12-gallon tank, a pump, delivery hose and a spray broom, which permits of spraying three rows of onions at a time.

The concentrated acid is pumped from the carboy direct to the mixing vessel.

The methods of operation and maintenance are described. Approximately one acre of onions can be sprayed per day, including all operations.

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No. 1. The outfit pumping concentrated acid from a carboy into a wooden tub filled with water.



No. 2. The application of the diluted acid by means of a 3-nozzle spray broom.



No. 3. The general arrangement of the pump. Note the $\frac{1}{2}$ " bore suction hose fitted to the elbow of the inlet valve.



“BLIGHTY WHEAT,” OR THE BLACKENING OF WHEAT EARS.

By L. OGILVIE.

Blackening of the ears of wheat is a common and well-known trouble in the Western Province, especially during wet seasons, and causes considerable alarm to farmers, who speak of it as “Blighty Wheat.” In the mind of the farmer the trouble is apt to be confused with Mildew, Smut and Take-all, all of which, it is true, can be associated with blackening of the ears. The fact that this discoloration is often accompanied by poor and badly shrivelled grain encourages the popular belief that “Blighty Wheat” is a definite disease. It can be induced, as will be seen below, by a considerable complex of factors, but the fungi actually causing the blackening are mildew (*Erysiphe graminis*), very important in 1942, *Cladosporium herbarum*, *Alternaria* spp., and to a lesser extent *Septoria nodorum*.

Previous Records. Among previous records may be mentioned that of F. T. Brooks, who, in his “Plant Diseases” (3), referring to *Erysiphe graminis*, states, “The fungus affects the lower parts of the stems as well as the leaves. In some wheat varieties, e.g. Benefactor, it occurs commonly on the glumes, where it is often followed by mould fungi such as *Cladosporium herbarum*, which cause blackening of the ears. Very susceptible varieties may be considerably weakened in their growth by mildew, and when the fungus attacks the stem severely it may be a factor in causing ‘lodging’ of the crop. Susceptibility is increased by heavy nitrogenous manuring.”

In his paper on the parasitism of *Cladosporium herbarum* and its relation to “Thinning Out” and “Deaf Ears” in wheat, published in 1928 (2), F. T. Bennett showed that this fungus is not parasitic in any stage or form on cereals, but is semi-parasitic, establishing itself on and thereby hastening the death of dying tissues. According to Bennett, “its presence on plants which ‘ripen prematurely’ and on others which yield few and shrivelled grains is a clear indication of an unhealthy condition induced by some more obscure cause.”

Weather Conditions and Blackening of Ears. The precise weather conditions favouring a severe attack of mildew are not very clear from the literature, but it appears that infection can take place at very low humidities (25 to 55%) (15), and that the conidia can germinate in moist air in the absence of drops of water (6). It seems that heavy rains following an abnormally dry period may favour an epidemic (5) and this is borne out by the observations described below.

The most interesting occurrence in the Bristol Province in past years appears to be in 1938 when the yield of wheat was reduced by mildew in many fields in the Marlborough (Wilts.) district, and Glume Blotch, caused by *Septoria nodorum*, was prevalent in Wilts. in September. In that year the drought from February to June was associated with severe attacks of mildew

on all the cereals. The month of July was dull, wet (3.94 in.) and cold, while rainfall in August was about normal.

In 1937 and 1940 the early summer was nearly normal in rainfall, but the rainfall in July was 3.99 in. in 1937 and 7.92 in. in 1940. In 1937 mildew was severe in Herefordshire and the Teme Valley, and was concerned in blackening of the ears, while glume discoloration in which *Septoria nodorum* and *Alternaria spp.* were implicated was common throughout the Province. In 1940 glume blotching, apparently due to *Septoria nodorum*, was very prevalent in Shropshire from July onwards.

In 1942 the months of February to April were dry. Mildew began to be strikingly apparent on the bases of the wheat stems in May. This month was very wet from about the 10th onwards, the rainfall being 5.12 in., 2.74 in. above the average. June was very dry (0.40 in.) and July dry (2.91 in.), while August was again wet (4.71 in.), 1.38 in. above the average. Sunshine in August was well below the average. In 1942 blackening of the wheat ears was very pronounced in some areas.

Details of Specific Instances in 1942.

1. Wincanton Area, Somerset.

Four severe instances of blackening of the ears were observed on the variety Wilma in this area. The first was on newly-broken grassland. The ears were severely blackened by mildew, *Cladosporium*, etc., on the glumes. Growth of the plants was vigorous and the grains were not badly shrivelled. An analysis of the soil showed Lime, trace; P_2O_5 , 0.0232% and K_2O , 0.0060%.

In the second, also after grass, growth was irregular, many of the plants being small, with a purplish discoloration of the stems. The soil analysis showed Lime, 5%; P_2O_5 , 0.0109% and K_2O , 0.0095%. In this case the upper grains were badly shrivelled.

In the third, after oats after grass, there were large patches where the plants had failed entirely. Little tillering had taken place. The soil analysis showed Lime, 5%; P_2O_5 , 0.0285% and K_2O , 0.0084%.

In the fourth, wheat after spring oats, the plants were very thin and irregular, and the ears very badly discoloured with mildew and other fungi, while the upper grains were very badly shrivelled. The soil analysis showed Lime, trace; P_2O_5 , 0.0161% and K_2O , 0.0045%.

The soils of all four fields showed low values for "available" potash, the two lowest values—Nos. 1 and 4—being associated with the worst discoloration of the ears. Mildew was prevalent on the glumes in all four crops and was associated with sooty fungi such as *Cladosporium herbarum*, etc.

2. Variety Trial, North Cadbury, Somerset.

This variety trial was laid down by the Somerset W.A.E.C. Growth was excellent in all varieties. The trial yielded interesting differences in the amount of blackening of the ears in the different varieties, the details of which are as follows:—

Squareheads Master. Mildew and *Cladosporium* on ears very severe. Crop laid badly.

Little Joss. Blackening of ears moderate. Badly laid.

Winter Victor. Some mildew on ears.

Wilma. Ears badly discoloured.

Juliana. Discoloration of ears slight.

Vilmonin 27. Ears fairly clean.

Holdfast and Desprez 80. Ears very clean.

It was noticed in this trial that the tall-growing varieties tended to become "lodged" and on these discoloration of the ears was severe. The short varieties, Holdfast and Desprez 80, on the other hand, probably allowed greater ventilation and the ears of these remained clean throughout.

It may be noted that Squareheads Master (Standard Red) is a notoriously weak-strawed variety. It is interesting also that the varieties in which the ears are relatively clean, Desprez 80, Holdfast and Vilmonin 27, are the first in order of ripening.

3. West Kennett, near Marlborough, Wilts.

A farm in this locality was visited on August 10th. A large field of Squareheads Master was found to be very badly blackened in the ear. The crop had had $1\frac{1}{2}$ cwt. of a complete fertiliser and was after oats after old pasture. The field was in an open situation but sloped to the east. Mangolds quite near showed patches of severe potash deficiency, while analysis of the soil from the vicinity of the blackened wheat gave the following results:—Lime, 10%+; P_2O_5 , 0.0041%; K_2O , 0.0036%, *i.e.* indicating a severe deficiency of potash. The ears were severely attacked by mildew and other fungi, *Cladosporium*, etc., and the grains were rather shrivelled.

A field of Wilma at a lower altitude was less severely affected. This was after swedes and mangolds and sugar beet fed off to sheep. The land was pot dunged before these. Blackening of the ears was slight. Soil analysis gave the following results:—Lime, 5%; P_2O_5 , 0.0881%; and K_2O , 0.0160%. Blackening of the ears appeared to be worse in a patch where poultry manure was applied, *i.e.* where the N/K ratio was probably unbalanced.

In another field of White Victor, part sloped west and part east. The latter had had vetches, etc., folded off and $\frac{1}{2}$ cwt. muriate of potash and 1 cwt. superphosphate applied. This part had the ears severely blackened. The other part, facing west, followed clover cut and fed off, followed by pot dung. Blackening was not so severe.

The grains on the badly blackened ears were well filled and there was little mildew on the ears, but other fungi, *Cladosporium*, *Alternaria*, etc., were present. The blackening in this case and in that of the Squareheads Master, a very susceptible variety, may have been partly associated with lack of exposure, the prevailing wind being from the west.

4. Cam, Glos.

An interesting example was observed at Coaley, Cam, Glos., on August 11. The field in question had been ploughed in March 1941 and sown to mixed corn, from which an excellent crop was harvested in the autumn. Wilma wheat was then drilled in October. This appeared healthy until coming into ear, when mildew was noticed covering the stems. Severe discoloration of the ears then developed in strips where a hedge had been removed and where farmyard manure had been tipped. The ears from the good strips had slight

mildew and *Cladosporium*, etc., and the grains were well developed, whereas from the bad strips the grains were shrivelled and covered with these fungi.

Where the hedge had been removed the ears were blackened and grains were badly shrivelled. The soil analysis was as follows:—Lime, trace; P_2O_5 , 0.0185%; K_2O , 0.0027%, *i.e.* an extremely low potash figure.

Analysis of the soil from the area where dung had been applied gave the following results:—Lime, trace; P_2O_5 , 0.0250%; K_2O , 0.0040%. In this area the crop was much laid.

A strip alongside where there was little discoloration gave the following analysis:—Lime, 0.1%; P_2O_5 , 0.0291%; K_2O , 0.0048%.

At this centre blackening of the ears where dung had been applied was attributed mainly to lodging and subsequent severe development of mildew, and where the hedge had been removed to potash deficiency. It should be noted that in all three cases the potash figure was very low.

5. *Eardiston, Worcs.*

This farm, situated in the Teme Valley, had a case of very considerable interest. In a field of wheat of the variety Als a large square had been "flagged," *i.e.* had had the tips of the leaves cut off on June 10th, in order to induce the plants to ripen their ears earlier. When the field was examined on August 13th the ears of the "flagged" square were very much blackened whereas the surrounding ears were much cleaner. Examination of the ears showed that they were severely attacked by mildew and that the grains were well filled.

The effect here was attributed to delay in ripening and to a more leafy growth being induced in the flagged portion, leading to less efficient ventilation. It was noticed that plants growing near the edge of the field, and thus receiving plenty of ventilation, were markedly clean.

Discussion.

It will be seen from the above instances that severe blackening of the ears of wheat may be brought about in a wet harvest season by a complex of factors, of which the following seem important:—

1. *Low Potash Status.* This delays ripening and leads to poor filling of the ears and shrivelled grain.

There are several records in the literature of the association of mildew of cereals with a low potash status. Spinks (11) found that wheat manured with potash had less mildew. Stuck (12) confirmed this and showed that the sclerenchyma and parenchyma cells of plants manured with potash had thicker walls. Arland (1) also showed that barley, manured with potash, was less susceptible to mildew and that the epidermal walls were thicker. Van Poeteren (13) found that both wheat and barley in trial plots not receiving potash suffered more severely from mildew than in those supplied with this material, while Lowig (9) found that wheat and barley plants receiving insufficient potash were uniformly infected with *E. graminis*, mostly in such a severe form that scarcely any ears were produced. Liberal supplies of potash in any available form resulted in a marked decline in the incidence of mildew, combined with an augmented yield, these effects being most noticeable with the

silicate. Thickening of the cell membranes of the leaves was believed to be the direct cause of increased resistance of the plants to mildew. In this connection Wagner (14) claims that soils rich in silicic acid are less liable to produce mildewed plants and that susceptibility to infection increases with rising H-ion concentration.

It may be noted that the addition to soils and culture media of lithium (8), manganese (4) and copper (10) respectively has been claimed to reduce the amount of mildew on cereals.

2. *Lack of Ventilation.* This may occur in low-lying fields or fields not exposed to the prevailing winds and in tall growing varieties such as Squareheads Master, Little Joss and Wilma. These varieties become lodged easily and aeration is then very poor.

It should be noted that top dressings of nitrogenous fertilisers may tend to produce blackening of the ears by upsetting the N/K balance in potash-deficient soils, by delaying ripening and by producing a leafy growth, lodging and consequent severe infection with mildew and sooty fungi.

Further studies are required to determine whether the shrivelled and blackened grain produced under such circumstances is of inferior milling quality, whether its germination is impaired and whether this can be improved by organo-mercury seed dressings; and whether any of the fungi in question are carried over from year to year in or on the grain.

Acknowledgment.

The writer is much indebted to Dr. D. A. Osmond for carrying out the soil determinations.

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THE TREATMENT OF APPLE POMACE PRIOR TO DRYING FOR SUBSEQUENT PECTIN EXTRACTION.

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For over 30 years some proportion of the residues from the cider presses has been dried and utilised for the extraction of pectin. The earlier production was largely centred at one factory, although certain jam manufacturers produced at least a part of their requirements for themselves. The production of pectin from English apples did not show any very large increases until the present war, probably on account of the fact that considerable quantities of dried apple pomace and powdered citrus pectin were imported from America and Canada.

The need to limit imports, however, created a new situation in 1940 and efforts were made to ensure that the maximum possible quantities of home-produced wet pomace should be dried and extracted. Certain difficulties were encountered. Farmers were in many cases extremely anxious to receive back from the cider mills the wet pomace from their particular loads of apples, the pomace being regarded as a feeding stuff of much value, especially in view of the shortage of other feeding materials. Cider makers were thus in some cases placed in a difficult position, as they quite naturally did not wish to lose the good-will of their suppliers of fruit.

Secondly, there were large numbers of farm cider-makers, who possessed no drying machines and who could not dry the pomace themselves. War-time conditions of transport did not allow of frequent movement of small bulks of pomace to a drying machine and very considerable quantities of pomace were never dried because of this particular difficulty. There was little doubt that in the winter season of 1942 the farm cider-makers in some districts would have been prepared to dispose of their pomace to a factory equipped with a drying machine, especially as the Ministry of Food had differentiated in price between pomace sold for cattle feed and for pectin production—to the considerable advantage of the latter.

In considering this point, it seemed that information was needed as to how a farm cider maker could preserve his pomace for a sufficient length of time to enable him to collect a large enough bulk to be sent either to a local factory to be dried or by rail to a more distant destination. It was learnt that certain of the cider factories themselves were not equipped with drying machines and consequently were in need of information regarding the length of time untreated pomace would keep without suffering an appreciable diminution in setting power. Consequently, a series of experiments was devised and carried out in the last 2 months of 1942. The scheme was simple in nature and was intended merely as a means of obtaining some information as quickly as possible which could be utilised during the 1943-4 season. The experiments themselves have indicated certain points which must be examined in more detail and the results given here must be regarded merely as a progress report.

The general scheme of the experiment was fully discussed with Messrs. Wm. Evans & Co., Ltd., and Messrs. H. P. Bulmer & Sons, Ltd., the only two firms authorised by the Ministry of Food in 1942-3 to extract pectin from pomace. The writers wish to express their very cordial appreciation of the help given by these firms in the persons of Mr. W. R. Bufton and Mr. Bertram Bulmer. Special thanks are due to Mr. Bulmer and his Chief Chemist, Mr. MacDowell, for the details of their method for testing the jelly strength of pomace extracts.

Experimental.

The various points which were examined in the experiments are given below:—

1. Effect of length of time of the drying process on jelly strength of dried pomace.
2. Changes in jelly strength of untreated pomace over a period of several days.
3. Effect on jelly strength of keeping wet pomace as a heap of disintegrated material or as a compact stack of press-cakes as they came from the cloths.
4. Effect of adding SO_2 to the pomace, either in form of 6% liquor or solid potassium bisulphite.

Factory and Laboratory Operations.

For most of the experiments, pomace was taken from the press in the cider-house and treated immediately. The material used was invariably pressed twice without any water addition and was then ready for experimental treatment. When the requisite time period had elapsed for any particular treatment, samples of approximately 1 cwt. wet pomace were disintegrated and fed straight into the Simon drier which had previously been heated up and which took about 30-50 minutes to reduce the moisture to a sufficiently low figure. These samples of 1 cwt. were taken from the main bulk and dried at approximately daily intervals from the commencement of the experiment up to one week. The Simon drier was operated on the batch principle, and when the moisture was considered to be below 10%, the whole of the dried product was run out, allowed to cool in a dry room, and, when cool, a 2 lb. sample of the pomace was taken carefully from the bulk and placed in a Kilner jar which was tightly stoppered. The rest of the sample was stored in sacks in the same room. Moisture figures were obtained on the pomace samples before drying and immediately after the dried pomace was cold.

This part of the experiment was completed before Christmas in 1942, but the jelly tests could not be carried out until February, 1943. The pomace samples were tested both from the Kilner jars and the sacks. The method involved extraction at a standard pH for 1 hour, under a reflux condenser. The viscosity of the filtered extract was taken at 30°C and from graphs provided, the amounts of extract required to make finished jellies of 2 different strengths were determined. The jellies were prepared in the usual way under strictly standardised conditions and poured into circular tins of 2½" diameter. The jelly tests were carried out next day on the B.A.R. jelly tester working to a standard deviation of 30°. All figures for jelly strength were expressed on the basis of moisture-free pomace, and each figure is an average obtained for 2 jellies, one strong and one weak.

Determination of Error Involved in Sampling and Analysis.

As a new technique was being employed for the first time on dried samples of a size of 30 or 40 lb. it became necessary to examine the problem of the error involved both in sampling the jars or sacks of material and in the actual determinations of jelly strength.

One of the experimental sacks of pomace was emptied out and well mixed by hand. Two Kilner jars were filled by random sampling from the whole mass of pomace. The contents of each jar were thoroughly mixed, and two separate samples weighed out from each jar. Each of the duplicates from the two jars was then treated as described above and two jellies prepared from each sample. In this way, eight determinations of jelly strengths were obtained. The two figures for the strength of weak and strong jellies from each sample of pomace were averaged and the four final percentages, on analysis, indicated that no differences in jelly strengths of less than 5% could be regarded as significant. This figure should be borne in mind in considering the results of the experiments. In further work, the experiments will be devised in such a way that full statistical treatment can be applied to the results.

Experiment 1. Effect of Length of Time of Drying Process on Jelly Strength of Dried Pomace.

A full load ($6\frac{1}{4}$ cwt.) of twice-pressed pomace from mixed bittersweet apples was fed as quickly as possible into the Simon drier and treated as a batch. The moisture content was 63%. Samples were withdrawn at intervals, spread out and allowed to cool before being sampled and put into Kilner jars and sacks. Moisture contents were obtained on the cool pomace by means of the Simon electric oven (15 mins. at 135°C.) and a further figure was ascertained at the same time as the jelly strength was determined. Table I gives the results.

TABLE I.

No.	Length of Drying Period. Mins.	Moisture in cold dry Pomace %	Kilner Jar Sample (9 weeks after drying).			Sack Sample (10 weeks after drying).		
			Moisture. %	Jelly Strength.	% Loss in Jelly Strength (Calculated on No. 3).	Moisture. %	Jelly Strength.	% Loss in Jelly Strength (Calculated on No. 1).
1	32	22.23	21.23	3.19	0.62	19.00	3.10	—
2	45	14.13	14.55	3.06	4.7	14.30	3.08	0.64
3	55	7.46	8.35	3.21	—	14.70	2.87	7.40
4	60	5.11	5.72	3.18	0.93	12.44	2.98	3.9
5	65	2.27	3.20	3.05	4.98	12.60	2.93	5.5
6	70	2.48	3.25	3.03	5.62	10.34	2.86	7.6
7	75	2.20	2.93	2.62	18.4	10.83	2.87	7.4
8	135	1.61	2.73	1.74	45.8	7.98	1.84	40.7

The first samples were purposely taken from the drier with a very high moisture content and the last sample was allowed to remain in the drier for an exceptionally long period which did not result in a commensurate reduction of moisture, but which merely resulted in a charring of the pomace. It will

be noted that whilst the moisture contents of the pomace stored in the Kilner jars had altered only slightly during 9 weeks' storage, the moisture content of similar samples in sacks had increased considerably, although in one case, that of the first sample, the moisture had fallen. These findings are easily explicable on the basis of an interchange of moisture between the pomace and the air—an interchange that was not possible in the glass jars.

In the Kilner jars series the pomace retaining 7.46% of moisture gave the highest jelly strength whilst the first sample, with 22-23% moisture had a similarly high quality, although such a water content might have been expected to have led to changes in the pomace which would have facilitated loss of pectin. No significant losses in jelly strength occurred as the moisture content was reduced to 2.48%, but a slightly longer period of drying (75 minutes) gave a pomace with 2.20% of moisture and this material showed a loss of 18.4% of jelly strength calculated on that of the best sample. The increased drying period employed for the last portion of the sample had raised the percentage loss in jelly strength to 45.8% without simultaneously reducing the moisture to a significant degree.

In the samples stored in sacks, which are, of course, of more immediate practical importance than the glass jar samples, there was no tendency for the jelly strength to fall to a noticeable extent as the moisture content in the dry pomace was reduced from 22.23 to 2.20%, but the extra period of heating of the last portion of the pomace showed a large loss. In considering these results, it must be emphasized that the original figure for moisture in the freshly dried pomace had altered considerably before the jelly strengths were determined. The experiment shows that pomace can be dried and maintained with a wide variety of moisture contents without causing any considerable differences of jelly strength over a period of 2 months. The importance of this result for the present work lies in the fact that the differences of moisture content shown in later experiments are not responsible in themselves for the variations in the jelly strength of the various samples.

Experiment 2. Storage of Wet Pomace in (a) Disintegrated or (b) Slab Form.

This experiment was carried out on the pomace from some Kingston Black apples of very uniform, sound quality. 8 cwt. of the second-pressed material was stored in the disintegrated form in a large heap covering an area of about 4' x 4', the pomace being 2' deep at the centre of the heap, and a similar quantity in the form of the cakes of pomace exactly as they were removed from the cloths. Although there was a certain amount of breakage around the edges, a practically vertical stack of the press-cakes was built up. Both heaps were covered with dry cider cloths. At various intervals, portions from the two heaps were disintegrated and dried in approximately 1 cwt. lots, the other treatments being identical with Experiment 1. The data are given in Table II.

TABLE II.

Method of Storing Pomace : Slabs (S), Ground (G).	Period between pressing and drying of Pomace, Days.	Temperature at Centre of Heaps of Pomace, °C.	Moisture Content of Pomace.		Kilner Jar Sample.			Sack Sample.		
			Before drying, %	After drying, %	Moisture, %	Jelly Strength.	% Loss in Jelly Strength.	Moisture, %	Jelly Strength.	% Loss in Jelly Strength.
—	Control : dried at once.	—	58.5	5.45	4.65	2.40	—	11.36	2.75	—
S.	1	—	59.5	6.20	6.29	1.73	28.0	12.05	1.68	38.9
G.	1	—	57.5	3.66	4.90	2.36	1.7	9.52	2.16	21.4
S.	2	37°	58.5	6.72	6.53	1.56	35.0	11.14	1.61	40.0
G.	2	35°	58.0	4.80	4.62	1.70	29.3	11.39	1.41	48.7
S.	3	38°	58.9	3.95	4.62	1.70	29.3	10.13	1.47	46.5
G.	3	43°	56.0	6.03	6.27	1.49	38.0	10.52	1.40	49.5
S.	3½	36°	59.8	10.13	9.83	1.53	36.2	11.82	1.42	47.6
G.	3½	46°	56.5	5.55	5.05	1.28	46.9	9.92	1.66	39.6
S.	6	30°	54.75	6.55	6.71	1.06	55.9	9.73	1.33	51.6
G.	6	53°	55.5	4.30	4.32	1.06	55.9	9.14	1.41	48.7

After the first day's storage there was a decided tendency for the temperature of the centre of the heap of pomace in slab form to fall over a 6-day period, but during this period a very much greater increase in temperature had occurred in the disintegrated pomace, probably owing to the manner in which the material settled down into a compact mass.

The moisture contents of the various batches varied from 3.66–10.13%. This was unavoidable as the small samples dried very rapidly at the end and there was no way of obtaining an analysis sufficiently quickly to determine the exact moisture content. The water contents of the stored pomaces after 9 weeks in sacks only varied between 9.14 and 12.05%.

The jellies from the dried pomaces showed remarkable losses in strength. Considering the sack samples, the losses on the 2 types of stored pomaces can be set out as follows :—

Days of Storage :	1	2	3	3½	6
Percentage loss in strength of jelly prepared from pomace stored in disintegrated form	21.4	48.7	49.5	39.6	48.7
Percentage loss in strength of jelly prepared from pomace stored in slabs	38.9	40.0	46.5	47.6	51.6

These figures indicate that very serious losses in jelly strength occurred in pomace stored by both methods, the losses for disintegrated and slab forms respectively on the first day of storage being 21.4% and 38.9%, and 48.7% and 57.6% after 6 days' storage. The intermediate values show no correlation and the experiment will have to be repeated with more closely controlled conditions to follow more accurately the changes taking place.

The experiment, however, does show that with this particular sample of pomace, serious deterioration of quality occurred after 24 hours' storage in either manner, and that the losses continued to the end of the experiment 5 days later.

The figures indicate that a serious loss occurs within 2 days of pressing the pomace. It has previously been generally accepted that, whilst it was desirable to dry the pomace within a few hours of the second pressing, no serious loss occurs within 2 days.

Experiment 3. Preliminary Trial of Preservation of Wet Pomace with SO₂.

The last 3 experiments of the series were concerned with the use of SO₂ as a preserving agent for the wet pomace. A small scale experiment was carried out in the laboratory to test the general efficiency of SO₂, and the results are given here.

The material used was twice-pressed Yarlinton Mill pomace obtained from apples in excellent condition. Five lots, each 10 lb. of pomace, were stored in chip baskets. One sample was kept without SO₂ as a control and each of the remaining 4 samples were treated with 6.7% SO₂ solution in such quantities that the SO₂ added to the pomace samples was 1,000, 1,500, 2,000, 2,500 p.p.m. respectively. The necessary volume of 6.7% SO₂ was made up to 100 ml. in each case with water so that the same total volume was added to each sample. The 5 samples were covered loosely with paper and set aside at the cider house temperature. When mould growth became extensive in the control sample (after 7 days) all the samples were broken up by hand and dried in steam ovens for 24 hours. The data collected during this experiment are given in Table III.

TABLE III.

Calculated amount SO ₂ added to wet Pomace : p.p.m.	Total SO ₂ in wet Pomace after 7 days' storage. p.p.m.	Condition of Pomace before drying.	Dried Pomace Strength.		
			Moisture. %	Jelly Strength.	% Loss in Jelly Strength calculated on figure for sample with highest SO ₂ content.
Control : no SO ₂	—	Very mouldy	3.95	2.47	28.0
1,000	15.7	Mouldy	3.85	2.92	14.9
1,500	130.4	Slightly mouldy	4.57	3.03	11.7
2,000	207.0	Traces of mould	3.72	3.27	4.7
2,500	304.0	Perfectly clean	3.93	3.43	—

In the first place, there were very considerable losses of SO₂ from the pomace. From an addition of 1,000 p.p.m. only 15.7 p.p.m. were retained after 7 days. The pomace was stored in the form of pieces of press-cake of about 2"—8" square, and thus the loss cannot be said to be due to the pomace being in a finely divided condition. Visible mould growth commenced on the control after 3 days and the gradations in the extent of growth in the other samples was roughly inversely proportional to the amount of SO₂ used. After 7 days, the pomace to which 2,500 p.p.m. SO₂ had been added was still perfectly free from visible mould and had a clean, sweet smell—the SO₂ being only just noticeable.

Secondly, only Kilner jar samples were taken and, as a standard for jelly strength, the sample with the highest strength (*i.e.* from pomace with 2,500 p.p.m. SO₂) was arbitrarily taken and the loss in jelly strength in the other samples expressed as a percentage of this figure of 3.43.

The use of only 2,000 p.p.m. of SO₂ did not result in a significantly lower jelly strength than the maximum dose of 2,500 p.p.m., but lower strengths of SO₂ gave proportionally weaker jelly strengths until from the control sample, with no SO₂, a dried pomace was produced which contained only two-thirds of the jelly strength of the best sample.

Experiment 4. Factory Test on Preservation of Wet Pomace with SO₂.

The previous experiment having shown the possibility of using SO₂ with some effect, a larger scale trial was attempted, using pomace in sufficient quantities to utilise the Simon drier.

The experiment started on 16/12/42, using 14 cwt. of twice-pressed pomace (from 80% Dabinetts and 20% mixed Somerset bittersweet apples, in rather poor condition). One sample of the wet pomace was disintegrated and dried at once. The bulk of the pomace was then collected into 2 large heaps, and to one of these was added 4.5 gallons of 2.3% SO₂ solution, which should theoretically have provided a concentration of 1,500 p.p.m. SO₂ in the pomace. The SO₂ was carefully added to one heap of pomace in a roughly broken up condition and the pomace turned over twice to obtain as good a distribution of SO₂ as possible. Each day afterwards, 1 cwt. of pomace was taken from each heap, disintegrated and dried in the Simon drier. SO₂ and moisture data were obtained. The relevant information is given in Table IV.

TABLE IV.

Method of Storing wet Pomace with or without SO ₂ .	Period between pressing and drying of Pomace. Days.	Temperature at Centre of heaps of Pomace. °C.	Moisture Content of Pomace.		SO ₂ Content of Pomace before drying. p.p.m.	Kilner Jar Sample.			Sack Sample.		
			Before Drying. %	After Drying. %		Moisture. %	Jelly Strength.	% Loss of Jelly Strength.	Moisture. %	Jelly Strength.	% Loss of Jelly Strength.
—	Control : Dried at once.	—	62.5	7.53	—	6.88	3.39	—	13.14	3.30	—
SO ₂ } no SO ₂ }	1	17°	63.5	5.28	924	5.44	3.17	6.5	12.32	3.22	0.24
	1	39°	64.9	6.79	—	6.97	3.05	10.0	11.25	3.14	4.9
SO ₂ } no SO ₂ }	2	38°	64.0	7.19	775	6.44	3.05	10.1	10.24	3.01	8.8
	2	47°5	61.1	9.36	—	9.10	2.66	21.5	12.74	2.87	13.0
SO ₂ } no SO ₂ }	3	44°	64.7	7.80	489	7.32	3.07	9.4	12.89	3.04	7.9
	3	49°	63.0	8.87	—	9.30	2.50	26.5	11.80	2.53	23.3
SO ₂ } no SO ₂ }	5	52°	63.5	9.56	262	9.50	2.92	14.0	12.72	2.87	13.0
	5	50°	60.3	9.33	—	9.13	2.41	28.9	10.06	2.26	31.4
SO ₂ } no SO ₂ }	6	—	59.3	9.87	137	7.54	2.61	22.0	13.28	2.48	24.8
	6	—	58.2	8.10	—	8.20	2.25	33.6	11.79	2.23	32.4

The following points are seen from an examination of the figures :—

(i) The temperature in the centre of the heap of sulphited pomace rose sharply from 17°C after 1 day's storage to 52°C after 5 days. On the other hand, the control heap heated very rapidly the first day (39°C) but then increased at a slower rate to 50°C after 5 days. Temperature could not be accurately taken on the 6th day, as the loss of heat from the small heap of residual pomace became a complicating factor.

(ii) There was no appreciable change in moisture content in the wet pomace during the 6 days. The dried samples varied between 5.28 and 9.87% immediately after drying.

(iii) The SO₂ content of 137 p.p.m. after 6 days agreed very closely with the figure of 130.4 p.p.m. after 7 days for a pomace to which 1,500 p.p.m. SO₂ was added in Experiment 3.

(iv) The moisture contents of the sack samples had all risen to figures ranging between 10.06 and 13.28% after 7 weeks' storage.

(v) The loss in jelly strength was not significant in pomace stored for 1 day before drying; wet pomace stored 2 days showed significant losses in both cases, the loss in the case of the control sample being double that of the sulphited sample. There was no very considerable further loss in jelly strength through storing the sulphited pulp for 3—5 days, but during this time the control samples deteriorated very considerably. The last day's storage tended to minimise, to some extent, the difference between the samples, but the final result was in favour of the sulphited pomace. The Kilner jar samples, despite their much lower moisture content, gave very similar results to their corresponding samples in sacks.

Experiment 5. Preservation of Wet Pomace with SO₂ and Potassium Metabisulphite.

The last experiment was included in the series to compare the results obtained by the use of sulphurous acid or of solid potassium metabisulphite for preserving the wet pomace. 14 cwt. of twice-pressed pomace from mixed cider fruit from the Long Ashton orchard were obtained from the press on 1/1/43; 1 cwt. was dried immediately. Two heaps of roughly broken press cakes, each of 5 cwt., were treated with 2.1 lb. of K.M.S. (45% SO₂) and 1.4 gallons 6.73% SO₂ respectively. A further cwt. was left without treatment. 1 cwt. samples from the two treated heaps were dried at daily intervals, and on the last day the untreated control was also dried. The data are given in Table V.

TABLE V.

Method of storing wet Pomace.	Period between pressing and drying of Pomace. Days.	SO ₂ Content of Pomace before drying. p.p.m.	Kilner Jar Sample.			Sack Sample.		
			Moisture. %	Jelly Strength.	% Loss in Jelly Strength (negative value indicates gain).	Moisture. %	Jelly Strength.	% Loss in Jelly Strength (negative value indicates gain).
—	Control: dried at once.	—	8.29	3.35	—	12.17	2.85	—
KMS } SO ₂	2	358	12.30	3.07	8.39	15.87	2.99	-4.0
	2	417	10.26	3.43	-2.1	13.05	2.91	-1.7
KMS } SO ₂	3	—	7.47	2.83	15.8	10.51	3.08	-8.0
	3	—	8.69	3.32	1.0	9.92	2.74	3.8
KMS } SO ₂	4	—	9.58	2.96	11.6	11.66	2.78	2.5
	4	—	8.29	2.82	15.9	10.82	2.53	11.2
KMS } SO ₂	5	—	8.35	2.75	17.9	11.55	2.18	23.5
	5	—	5.07	2.78	17.0	10.15	2.35	17.5
KMS } SO ₂	7	67	10.28	2.30	31.3	12.47	2.11	26.0
	7	93	10.05	2.29	31.6	12.37	1.97	31.0
—	7	—	10.09	2.22	33.7	12.95	2.13	25.3

The moisture contents of the dried pomaces immediately after cooling were not ascertained, but they can be taken as being approximately the same as for the Kilner jar samples.

The SO_2 content had fallen in the heaps at the end of the experiment to a very low figure. Intermediate estimations were not carried out.

The following points are of interest :—

(a) The jelly strengths from the pomace stored in sacks exhibit certain phenomena for which an explanation is not at present available. If the figures are examined in the light of the previous remarks on the significance of the results, it will be seen that there is a slight increase in efficiency in storing the pomace with K.M.S. rather than with SO_2 , but the difference is so small that it is impossible to make a more precise statement at this stage. Other factors which were not considered or controlled have probably affected the course of the experiment.

(b) Kilner jar samples do not show any special points of note, although it is interesting to observe the significant difference in jelly strengths for the control samples in Kilner jars and in sacks. The gains in jelly strength noted in the sack samples were not shown by the pomace stored in the glass jars.

Discussion.

The chief results from Tables II, IV, and V have been collected and are presented in Table VI to enable a general idea of the whole of the experimental results to be obtained.

TABLE VI.

Code.	Expt. No.	Method of storing wet pomace before drying.	Strength of Jelly from Control Sample of pomace.	% Loss in jelly strength (negative values indicate a gain) after storage of wet pomace for :						
				1 day.	2 days.	3 days.	4 days.	5 days.	6 days.	7 days.
A.	2	In slab form	2.75	38.9	40.0	46.5	47.6	—	51.6	—
B.	2	Disintegrated	2.75	21.4	48.7	49.5	39.6	—	48.7	—
C.	4	Preserved with SO_2	3.30	0.24	8.8	7.9	—	13.0	24.8	—
D.	4	No. SO_2	3.30	4.9	13.0	23.3	—	31.4	32.4	—
E.	5	Preserved with K.M.S.	2.85	—	-4.0	-8.0	2.5	23.5	—	26.0
F.	5	Preserved with SO_2	2.85	—	-1.7	3.8	11.2	17.0	—	31.0

When the behaviour of pomaces in different experiments is examined and compared (*i.e.* B and D ; C and F) it must be remembered that the pomaces were produced from different lots of fruit and no direct comparison of the storage treatment is possible. In fact, it would seem that the variety and pre-milling history of the apples may have a most important influence on the keeping quality of the wet pomace. This may account for the widely differing series of figures in the two experiments.

The figures for A and B indicate that very substantial losses of jelly strength occurred during 1 day's storage, whether in slab or disintegrated form, the losses increasing up to 6 days. Preservation with SO_2 delayed the loss of setting power from the beginning of the storage period (C, D).

The results in general indicate that under normal cider making conditions, losses in setting value of the pomace are likely to be very variable and to depend on a variety of factors, but it is evident that every possible effort should be made to dry the wet pomace immediately after it has been pressed, and the adoption of some form of preservation with SO_2 is desirable in all cases where some delay may occur.

Summary.

1. The effect of delaying the drying of wet apple pomace on the setting quality of the extracted pectin for the formation of sugar-acid-pectin jellies has been examined.

2. Very considerable losses occurred when wet, twice-pressed pomace was stored either in slab or disintegrated form during a period of 6 days, approximately half the loss having occurred during the first day's storage.

3. Treatment of the pomace with 1,500 p.p.m. SO_2 had a noticeable effect in retarding losses in jelly strength, especially in the first 3 days' storage.

4. A suggestion is advanced that as the losses in jelly strength occurring during the storage of the wet pomace were very variable, other factors, such as the variety and the condition of the fruit prior to milling, may also have an important bearing on the quality of the pomace.

APPLE POMACE SILAGE.

REPORT ON EXPERIMENTS CONDUCTED IN 1941.

By V. L. S. CHARLEY, A. W. LING M.Sc. (Berkeley Square Centre), and
E. L. SMITH, B.Sc. (Berkeley Square Centre).

Objects of the Experiments.

As a result of various chemical analyses which have been carried out from time to time on apple pomace, both before and after the pectin has been extracted therefrom, it has been suggested that the extraction process does not greatly reduce the feeding value of the pomace. Owing to the increased demand for pectin by the preserve manufacturers and the consequent increase in the amount of extracted pomace being made available, the University of Bristol Agricultural Advisory Centre was approached by the Ministry of Agriculture with a view to collaborating in experiments to compare the feeding value of the two materials. At the same time it had been suggested that silage made from pomace mixed with grass cuttings as a means of balancing the material might also have distinct possibilities.

It was decided to investigate these points and also to examine experimentally a suggestion put forward by Dr. H. E. Woodman that pomace might be ensiled with chopped straw, the idea being that the pomace might exert a softening effect on the straw and thereby improve its feeding value.

Four small-scale silage-making experiments were conducted at the Long Ashton Research Station with the object of obtaining information on the type and feeding value of silage which would result from ensiling:—

- (1) Unextracted apple pomace with the addition of agricultural salt.
- (2) Extracted apple pomace alone.
- (3) Extracted apple pomace mixed with grass cuttings.
- (4) Extracted apple pomace mixed with chopped oat straw.

Materials and Methods.

The silos used in the four experiments were similar and consisted of covered, cylindrical, galvanised iron drums, 7 ft. in height, $3\frac{1}{2}$ ft. in diameter, giving a capacity of approximately 67 cu. ft. A pit of about four feet in depth was excavated in the soil to accommodate the drums.

The pomace used throughout the series of experiments consisted of the residue from one batch of pressings. It was divided into two portions, one of which was retained for Experiment I and the other extracted so as to remove pectin.

The grass cuttings used in Experiment III were from very coarse winter herbage of poor feeding value. It was anticipated that the experiments would have been carried out at a time when good quality autumn grass would have been available, but unavoidable delays occurred which made this impossible.

The only other materials used were agricultural salt and chaffed oat straw.

The weighing, preparation and mixing of materials was carried out in adjacent buildings and the mixtures were sacked up for convenience of transport to the silos. The first experiment was commenced on February 6th, the others

following during the succeeding days. All silos were opened for inspection and sampling on August 22nd.

A feeding-stuffs analysis was carried out on samples of the materials collected at the time of ensiling and also on samples of the finished silage. pH determinations were made on the expressed juice.

Experiment I.

For this experiment 2 cwt. of agricultural salt were intimately mixed with 13 cwt. 1 qr. and 2 lb. of unextracted pomace. The method adopted in ensiling this and the other mixtures followed the accepted practice of silage making. Each sackful of material was well trampled before continuing with the filling, particular attention being given to the edges to ensure that no air pockets were left where micro-organisms could establish themselves. It was found that the mixture readily consolidated itself so that only moderate pressure was required to ensure a sufficient degree of compaction. The filling was completed in one day, the mixture occupying a depth of 5 ft. 6 ins. Sacks were placed in position on top of the mixture and were covered by a layer of soil about 6 ins. in depth.

Inspections carried out during the following days showed that there was no tendency for the silage to settle further in the container, neither was any perceptible rise in temperature noted. No further attention was given until the time of opening the silos.

The silage which was ultimately obtained was found to have a pleasant, slightly acidic odour which appeared to be mainly that of lactic acid. It appeared to have undergone no noticeable change in appearance during the time it was in the silo. It was also satisfactory to note that there was very little waste material, and what there was appeared to be confined to the top layers which had become sodden through the ingress of rain.

The analytical data for the samples taken in connection with this experiment are shown in Table I. The composition of the original mixture has been calculated from the weights of materials taken and the percentages are shown for comparison.

TABLE I.

	Unextracted Pomace.	Pomace + Salt Silage.	Composition of original mixture.
	%	%	%
Total Moisture	64.48	78.60	56.04
Crude Protein	2.28	1.07	1.98
Crude Fibre	8.08	3.67	7.02
Ash	0.67	6.94	13.54
Ether Extract	0.91	0.04	0.79
Carbohydrates	23.58	9.68	20.49
pH.	2.81	2.70	—
Constituents on Dry Matter Basis.			
Crude Protein	6.42	5.00	4.51
Crude Fibre	22.74	17.15	15.97
Total Ash	1.90	32.42	30.80
Ether Extract	2.57	0.17	0.18
Carbohydrates	66.37	45.26	47.71

The values in the first column show that the unextracted pomace had slightly higher values for moisture, fibre and ether extract than the average analysis for this material. The analysis of the finished silage, shown in the second column, reveals a considerable increase in the moisture content which was mainly due to the entrance of rain. A comparison between the second and third columns shows that in the dry matter constituents there had been some loss of carbohydrate material which had been balanced by small relative increases in the percentage figures for the remaining constituents. The slight change noted in the pH value cannot be regarded as having any significance, but it is to be noted that the acidity was high. It will be seen that almost one-third of the dry matter consisted of ash of which the greater proportion was salt.

Experiment II.

This experiment consisted of ensiling 15 cwt. of apple pomace from which the pectin had previously been extracted commercially. As in the previous experiment it was noted that there was no apparent tendency for heating to occur at the time of filling and during the succeeding days, and moreover no contraction in bulk was observed.

The appearance of the silage at the time of opening the silo was satisfactory and there were no signs of decomposition or mould growth. The odour was pleasant, somewhat acidic and suggestive of mild lactic fermentation. There was no waste material either on the top or sides and moisture had been effectively excluded. Table II shows the analytical data for the pomace and for the finished silage.

TABLE II.

	Wet Pomace.	Dry Matter Constituents.	Fresh Silage.	Dry Matter Constituents.
	%	%	%	%
Moisture	79.19		80.10	
Crude Protein ..	1.96	9.41	2.17	10.92
Crude Fibre ..	6.95	33.39	7.02	35.26
Total Ash ..	0.49	2.36	0.35	1.78
Ether Extract ..	0.76	3.65	0.80	4.02
Carbohydrates ..	10.65	51.19	9.56	48.02
pH.	3.61		3.14	

A comparison between Table I and Table II shows that the extraction of the pectin brought about a decrease of the carbohydrate fraction of the dry matter from 66.37% to 51.19%, there being a relative increase in the remaining constituents. It would also appear that soluble acids had been removed thereby causing an increase in the pH value from 2.81 to 3.61. During the time the pomace was in the silo there was a slight increase in the moisture content, but the composition of the dry matter appeared to have changed as a result of fermentation of part of the carbohydrates. A fall in percentage of carbohydrates occurred accompanied by a corresponding increase in the percentages of the other constituents except in the case of the ash which had unaccountably decreased. An increase in acidity had taken place, the final pH value being only slightly above that of the unextracted pomace.

Experiment III.

For this experiment the materials ensiled consisted of a mixture of the extracted pomace together with grass cuttings. The quantities used were :—

Extracted Pomace	..	..	..	12 cwt.	1 qr.	12 lb.
Grass Cuttings	..	..	..	2 cwt.	2 qrs.	15 lb.

Some difficulty was experienced in obtaining an intimate mixture chiefly owing to the fact that the pomace was not readily broken up into small pieces. It was found to be quite easy to tread the mixture into a fairly solid mass in the silo.

The finished silage which was obtained as a result of this experiment was found to have a good colour and appearance and was free from objectionable acids such as butyric. The smell was predominantly that of acetic acid ; mould growth was absent and there appeared to be a negligible amount of waste. The materials did not seem to have contracted in bulk as a result of ensiling. Table III shows the analytical data for the samples taken in connection with this experiment. The figures in the third column of the table have been calculated from the known weights of materials originally taken and are given as a guide in following the changes which took place.

TABLE III.

	Grass Cuttings.	Silage.	Analysis of original mixture.
	%	%	%
Moisture	78.16	76.30	78.98
Crude Protein	2.38	2.67	2.03
Crude Fibre	7.45	6.88	7.04
Total Ash	2.37	1.67	0.83
Ether Extract	0.56	1.02	0.72
Carbohydrates	9.08	11.46	10.36
pH.	—	2.69	—
Constituents on Basis of Dry Matter.			
Crude Protein	10.88	11.26	9.68
Crude Fibre	34.09	29.04	33.52
Total Ash	10.83	7.03	3.92
Ether Extract	2.58	4.30	3.45
Carbohydrates	41.62	48.37	49.32

A comparison of the dry matter constituents shown in the second and third column of the table indicates that there was a relative increase in the percentage of crude protein, ether extract and total ash at the expense of carbohydrates and crude fibre. The decrease in crude fibre and the relatively high increase in the mineral ash are interesting features because this result might be anticipated if the pomace had had a softening effect on the fibrous constituents of the grass and rendered these somewhat more soluble. It would, however, be hazardous to draw a definite conclusion from the one experiment. A significant fall in the pH value occurred, from 3.61 to 2.69.

Experiment IV.

The main object of this experiment was to determine whether pomace

mixed with chopped straw would have the effect of softening the fibre of the latter and possibly increase its feeding value.

A mixture consisting of four cwt. of chaffed oat straw and eight cwt. of extracted pomace was used for the experiment. Weight for weight the bulk of oat straw was found to exceed that of the pomace by a huge margin; moreover, the nature of the pomace being such that its disintegration was difficult made it impossible to obtain a homogenous mixture. The final mixture consisted of a large bulk of chaff through which large pieces of pomace were scattered. At the time of filling it was found impossible to obtain a sufficient degree of consolidation owing to the dry nature of the straw.

When the silo was opened up for examination it was found that mould attack had been so severe that the silage was quite unfit for consumption and had to be discarded.

Feeding Experiments.

It was originally intended to carry out feeding experiments at the Long Ashton Research Station farm, but owing to the compulsory ploughing of the remaining grass-land it became necessary to dispose of the horned stock. Arrangements were made with a neighbouring farmer who kindly consented to carry out simple feeding trials with fattening bullocks. The results of these experiments were as follows:—

(a) The silage made from unextracted pomace with added salt was not attractive and the stock refused to eat it, no doubt on account of the high salt content.

(b) & (c) The silage was most acceptable to the stock, which showed a slight preference for the silage containing the grass.

Conclusions.

It would appear that it is quite a simple matter to ensile extracted pomace alone, and that this could be done on the farm without having to resort to the use of any special equipment. The silage obtained is of a distinctly acid character, but is quite palatable and is readily eaten by stock. It would be misleading to infer that the unextracted pomace could be so ensiled owing to the fact that this material has such a high population of micro-organisms whose activities may be expected to bring about serious decomposition and possibly lead to very undesirable results.

It would seem that unextracted pomace can be easily conserved by addition of salt, but the quantity of the latter will need to be carefully controlled so that the resulting silage is not rendered unpalatable.

Grass cuttings and extracted pomace can be ensiled satisfactorily in the form of a mixture. The resulting silage has a low pH value, but the mixture is quite palatable and readily acceptable to stock. It would seem that lawn clippings would be the ideal form in which to use the grass and their high protein content coupled with the carbohydrate character of the pomace should result in a balanced feeding stuff. There is some reason to believe that the pomace may have a softening effect on some of the fibre constituents of the grass.

Silage made from chopped oat straw and extracted pomace may be feasible, but careful consideration must be given to the bulk factor and to the

state of division of the pomace. It can be said, however, that only a comparatively small weight of straw can be utilised in this way.

Summary.

1. Experiment shows that unextracted apple pomace can be conserved in the form of silage by the addition of agricultural salt. A high salt content is objectionable and renders the silage useless from the point of view of feeding value.

2. Extracted apple pomace can be satisfactorily ensiled without the addition of other materials. It yields good quality silage which is readily eaten by stock.

3. The amount of waste material in silage made from apple pomace is almost negligible provided simple precautions are taken during ensiling.

4. No special attention or equipment is required in making silage from apple pomace.

5. Extracted apple pomace can be ensiled as a mixture with grass cuttings, suitable proportions being 1 part by weight of grass to 6 parts of the pomace. The silage is palatable, distinctly acid, but readily eaten by stock.

6. Chopped straw and extracted apple pomace are not readily ensiled together in a mixture owing to the great disparity in bulk of the components and the difficulty in breaking down the pomace to ensure even distribution. These considerations limit the weight of straw which can be used in this way.

THE DEVELOPMENT OF ACIDITY IN CARROT JUICE AND TREACLE AND THE NATURE OF THE ACID PRODUCTS.

By A. POLLARD.

The low acidity of carrot juice (0.05% calculated as malic acid) is a great advantage from the point of view of concentration, and carrot treacles, therefore, are extremely sweet products. Nevertheless, on several occasions somewhat greater acidities in concentrates and treacles than those expected have been noted, i.e. on concentration the sugar content seems to have increased at a less proportional rate than the acid content. This was believed to be due to alcoholic fermentation followed by acetification:—Sugar—alcohol—acetic acid. On one occasion, when a large experimental batch of carrot juice fermented during the cooling period following clarification by boiling and skimming, most remarkable rises in acidity were noted, an original acidity of less than 0.1% rising to over 1% in a few days. But of this increase in acid content not more than a half was determinable as volatile acidity.

In the winter of 1941—1942 the production of carrot treacle was carried out on a commercial scale under the supervision of the Fruits Products Section and on behalf of the National Vegetable Marketing Company. During the course of the work, the problem of acid formation in carrot treacle arose more acutely. On one occasion, when it was necessary to hold a large batch of juice over a period of days, it was found that the resultant treacle developed masses of rapidly growing crystals on cooling and within six hours the treacle had set into a sticky plastic mass. The sugar content was very low, 28.4%, and the free acid content was exceptionally high (2.33%). Yet the juice had not shown any signs of active alcoholic fermentation.

It therefore appeared that carrot juice, on being kept in a non-sterile condition, could undergo a type of fermentation in which sugar was converted into acid; and that if this process had occurred to any appreciable extent, the treacle made from the juice would become semi-solid and lose its fluidity. This occurred in the commercial production wherever carrot juice was held over between expression and concentration for more than 24—36 hours, though in some cases the results were only slightly noticeable. The free acidities of such treacles varied from about 1.0% in those slightly affected, to over 2% in the more serious cases.

(a) *The Development of Acidity in Carrot Juice.*

Some experiments were carried out in order to follow the actual changes taking place in carrot juice when the naturally occurring yeasts and bacteria develop in it. These showed definitely that within 24 or 48 hours the sugar is rapidly removed and simultaneously the acidity increases. (Tables I, II). There is little or no production of alcohol, and the fall in specific gravity is not marked so that the process cannot be regarded as a normal fermentation.

TABLE I.

Time in days.	Specific Gravity.	% Total free acid as malic.	% Volatile acid as acetic.	% Total Sugars.	% Invert Sugars.	% Sucrose.	% Alcohol.
0	1.041	0.07	0.036	6.84	3.17	3.67	Nil
1	1.036	0.16	0.075	—	—	—	Nil
2	1.0355	0.69	—	2.70	2.70	0	—
3	1.0315	0.96	0.40	1.67	1.67	0	Nil
4	1.029	1.12	0.42	1.02	1.02	0	—
6	1.023	1.15	0.41	0.57	0.57	0	0.21
7	1.0245	1.21	0.43	0.57	0.57	0	—
8	1.026	1.18	0.45	0.61	0.61	0	—
9	1.026	1.21	0.55	0.54	0.54	0	—
10	1.026	1.19	0.53	—	—	—	—
11	—	1.17	0.61	—	—	—	—
13	1.0185	1.04	0.70	—	—	—	—

TABLE II.

Time in days.	Specific Gravity.	% Total free acid as malic.	% Volatile acid as acetic.	% Total sugars.	% Invert sugars.	% Sucrose.
0	1.038	0.09	—	6.00	3.30	2.70
1	1.036	0.17	0.08	5.78	4.82	0.93
2	1.0355	0.31	0.15	5.01	4.85	0.16
3	1.032	0.75	0.48	2.97	2.97	0
4	1.031	0.89	0.40	2.35	2.35	0
5	1.030	1.04	0.53	1.86	1.86	0
7	1.030	1.13	0.53	1.61	1.61	0
8	1.026	1.24	0.73	0.59	0.59	0

N.B.—No alcohol was found at any stage of the experiment. (These data were obtained by Mr. D. P. Hopkins).

It was also established that the sugar disappears by the process :—Sucrose—invert sugar—acid ; actual increases in the invert sugar at the expense of the sucrose in the first day of change having been recorded. It is, therefore, evident that delay in concentrating the juice after its expression involves not only an increase in its acidity but also a fall in its sugar content.

In a further experiment, similar juice was sterilised by boiling and was then inoculated with cider yeast. In this case fermentation proceeded normally with rapid losses of sugar and with a fall in specific gravity but with only a small increase in acidity. Alcohol was produced as the main product of the fermentation. It is, therefore, clear that the fermentation changes occurring naturally in carrot juice are not initiated by yeast of the *saccharomyces* type.

(b). *The Nature of the Acid Material.*

Although it has been shown that the treacle produced from fermented carrot juice possesses a high acidity, the amount of free acid present gives no indication of the amount of total acid produced by the fermentation process. For a considerable amount of acid has been found present as neutral salts and this is not estimated by the usual titration with alkali. For example, one very acid treacle had a titratable acidity corresponding to 35 ml. of normal

acid per 100g ; but the total acid present, both free and in a combined state, was equivalent to 88 ml. of normal acid per 100g. The treacle was found to have a high ash value, the total ash of this particular treacle being 6.54% (water soluble ash 5.41%) ; this would, therefore, account for the neutralisation of a considerable amount of the acid. The presence of nitrogenous compounds such as amino acids would also have a neutralising effect. That such compounds were present is indicated by the values for dialysable nitrogen (0.48%) and for amino nitrogen (0.2%).

An analysis of the acids present in the treacle was carried out, using as a starting material the mixture of acids obtained by ether extraction of the treacle after acidification to pH 1 with sulphuric acid (1). The titration curve of the extracted acids suggested that the chief constituent of the mixture was a mono-basic acid with a pK of about 3.7. Subsequent analysis confirmed this, for the acid present in the greatest amount was found to be lactic acid (pK 3.84), as shown in the table below.

TABLE III.
COMPOSITION OF ACID MIXTURE.

Lactic acid	..	..	..	67.0%	of total
Volatile acids	..	..	..	14.7%	
Succinic acid	..	..	..	7.2%	(approx.)
Malic acid	..	..	..	0.8%	
Oxalic acid	..	..	..	1.0%	
				90.7	

The amount of lactic acid, which was estimated by the method of analysis of Gordon and Quastel (2), would correspond to about 5.3% by weight of the original carrot treacle. The greater part of this would, however, occur in the form of salts. A direct estimation of the total lactic acid in the treacle itself gave a value of 4.4%, but in this case the presence of large quantities of sugar and other materials would be expected to interfere and to give a low result in the analysis.

The remainder of the acid mixture was found to consist chiefly of volatile acid (acetic) and succinic acid, the latter being characterised as the p-phenyl phenacyl ester. In the original juice before concentration, the volatile acid fraction would no doubt make up a greater proportion of the whole (c.f. Tables I and II), but during the concentration process a considerable part of this would pass off into the condensate. Estimations of malic acid and of oxalic acid showed that these compounds were present in traces, but no evidence could be found for the presence of citric acid. It is probable that a considerable number of other acids were present in small amounts, as would be expected in a product which had undergone fermentation.

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PRODUCTION OF BLACK CURRANT SYRUP.

A. UTILISATION OF POMACE RESIDUES.

B. PRODUCTION OF SYRUPS WITH HIGH ASCORBIC ACID CONTENTS.

By V. L. S. CHARLEY, MARGARET E. KIESER and JOAN STEEDMAN.

Various aspects of the process of preparing black currant syrup have been examined with a view to obtaining the most efficient extraction of ascorbic acid (A.A.) from the fruit and its retention in the final product. The question whether the black currant syrup could be produced in a more concentrated form has also been considered with the object of saving space in transport and storage. The question of concentration also arose in connection with the use of canned black currant pulp for syrup production. Canning resulted in the dilution of the product with 10—20% of water and in certain cases, where varietal or seasonal factors were involved, the A.A. content of the expressed juice fell so far below that of a normal fresh juice that the required amount of A.A. could not be achieved in the syrup without some form of concentration.

Some attention was given to these points during the 1942 fruit season. Although storage results for only 6 months have so far been obtained, these are included here in order that the results may be available for the 1943 season.

A. Utilisation of Pomace Residues.

The residual pomace from black currants that have been efficiently enzymed and pressed still contains from 55—65% moisture and a considerable amount of ascorbic acid, but these figures cannot be reduced appreciably by further pressing. The extraction of certain water-soluble compounds such as sugars and tannins from twice-pressed apple pomace, however, was adapted to the black currant material and the various experiments are described below.

(a) *Effect of volume, temperature and aeration of extracting water.*

500 gr. lots of once-pressed black currant pomace, containing 130 mgs. A.A./100 grs., were extracted with varying quantities of water for a standard period of $\frac{1}{2}$ hour. The water was added either hot or cold, and in some cases the water had been first boiled thoroughly for 15 minutes. In one experiment the pomace and water were boiled for the whole $\frac{1}{2}$ hour. At the end of the $\frac{1}{2}$ hour, the pomace was pressed out in a small press, using the same hand pressure in each case. The A.A. data was ascertained at once on each sample. Table I contains the more important figures.

TABLE I.

EFFECT OF VOLUME, TEMPERATURE AND AERATION OF EXTRACTING WATER.

Extractant.	Volume water in mls.	Volume of extract pressed out. mls.	Specific Gravity of extract.	A.A. in extract (mg/100grs.)	A.A. in total extract. (grs.)	Extraction A.A. as % of total in pomace.
Cold tap water.	900	840	1.009	38	0.319	49.1
" " " " " " " "	600	581	1.015	48	0.279	42.9
Cold, boiled distilled water	900	855	1.011	40	0.342	52.6
" " " " " " " "	600	660	1.016	47.6	0.314	48.3
Hot, boiled distilled water	900	860	1.016	50	0.429	66.0
" " " " " " " "	600	575	1.022	59	0.339	52.1
Water & pomace boiled for $\frac{1}{2}$ hour	900	670	1.027	67	0.449	69.1
" " " " " " " "	600	550	1.030	61	0.336	51.7

Whilst boiling for the full $\frac{1}{2}$ hour has not given appreciably better extraction than hot water, both cold unboiled and cold boiled water extracted much less A.A. from the pomace. The distillation and deaeration of the cold water gave higher A.A. figures in the extract, but these increases are probably due rather to the loss of less A.A. by oxidation than to the extraction of more A.A.

(b) *Effect of length of time of extraction.*

8lb. of pomace was thoroughly and quickly mixed with $1\frac{1}{2}$ gallons of boiling water and allowed to cool slowly to atmospheric temperature. Samples were taken at intervals and the extract obtained by pressing. The A.A. content in the original pomace was 112 mgs/100 grs. It follows that if the samples in each case were pressed to the same degree of moisture as the original pomace, the theoretical possible A.A. content of the extract would be 39.1 mgs/100 mls. Table II gives the data obtained in this experiment.

TABLE II.

EFFECT OF LENGTH OF TIME OF EXTRACTION.

Length of extraction period.	Temperature of mixed pomace and water.	A.A. in extract. (mgs/100 mls.)
3 minutes	65°C	31
10 " " " " " "	63°C	36
20 " " " " " "	60°C	36
30 " " " " " "	60°C	38
50 " " " " " "	55°C	39.5
2 hours	49°C	39.5
$3\frac{1}{2}$ " " " " " "	45°C	31.0
22 " " " " " "	19°C	25.2

The extraction reaches a well-defined optimum after 30 minutes and this value is maintained up to 2 hours, after which the extract shows a rapid loss in A.A. Many other experiments have confirmed this result, and $\frac{1}{2}$ hour can be taken as the maximum useful period for an extraction process of this type.

(c) *Effect of volume of extracting water.*

A number of samples of pomace of constant weight were extracted with varying volumes of boiled-out water added at boiling point. The temperature of the pomace + extracting liquor fell to 45–48°C at the end of the extraction period, which was between 45 and 85 minutes. The pomace, at the time of the extraction, contained 73 mgs. A.A./100 grs. The 250 grs. used for each experiment thus contained a total of 182.5 mgs. A.A. Table III gives the results.

TABLE III.
EFFECT OF VOLUME OF EXTRACTING WATER.

Volume of extracting water, mls.	Length of extracting period in minutes.	Temperature at end of extracting period.	Volume of extract, mls.	Specific Gravity of extract.	A.A. in extract in mgs/100mls.	A.A. in total extract. (mgs.)
300	45	45°C	320	1.015	32.4	103.7
450	50	47°C	457	1.011	30.5	139.4
600	55	48°C	600	1.008	28.1	168.6
750	63	48°C	730	1.006	27.5	200.7
900	70	48°C	870	1.004	22.6	196.4
1050	75	47°C	1040	1.003	19.0	197.6
1160	85	45°C	1110	1.004	18.3	203.0

The weights of A.A. extracted by the four largest volumes of water are practically identical, but the lowest of these, *i.e.* 750 mls. water to 250 grs. pomace, represents 30 gallons of water per cwt. of pomace. Thus, 5 cwt. of pomace (the average weight from 1 ton of fresh fruit) would need treatment with 150 gallons of water. The pure juice from the first pressing of 1 ton of currants is usually only between 140–160 gallons and the pomace extract would thus have to be reduced in bulk to a very considerable extent. The decision as to whether it would be economical to carry out an extraction on this scale would depend on the relative amounts of A.A. obtained from the pure, fresh juice and the pomace extract and also on the evaporative capacity of the factory concerned.

B. Production of Syrups with High Ascorbic Acid Contents.

(a) *Concentrated syrup from canned black currants.*

32 A.10 cans of pulped black currants (*i.e.* 2 cwt.) from the 1941 crop were mixed and treated with 30.5g. Pectinol 10.M. (an experimental material received through the Ministry of Food from U.S.A.). The enzyme was allowed 16 hours to complete its work and the pulp was pressed out. 29 lb. of twice-pressed pomace was obtained and this was boiled with 5 gallons water and repressed. The various yields were as follows:—

1st pressing:	15 gallons juice containing	95mgs. A.A./100mls.	(86.7% of total extracted).
2nd "	1.4 " " "	73.5 " "	(6.4% of total extracted).
boiled extract:	5.5 gallons extract "	20.7 " "	(6.9% of total extracted).

The three liquors were mixed, centrifuged, and evaporated in the Kestner machine. The yield from 20 gallons of juice was $6\frac{3}{4}$ gallons, to which $2\frac{1}{2}$ pints of ester liquor were added. From this material, 2 gallons of concentrate were mixed with $15\frac{1}{2}$ lb. sugar, giving 3 gallons of syrup which was preserved with 350 p.p.m. SO_2 added as the sodium salt.

Various analyses for these intermediate or end products are given below : -

Sample.	Specific Gravity.	Acidity as malic acid % (wt/vol.)	Ascorbic Acid mgs/100mls.	Total Ascorbic acid. (AA+DHA) mgs/100mls.
Mixed pressings & extract ..	1.040	2.0	66.4	89.0
Concentrate	1.102	—	159.0	—
Syrup	1.264	3.32	107.5	124.0

The A.A. figure of 66.4 mgs./100 mls. for the juice would have been much too low to enable a straight syrup to have been made with an A.A. figure up to the required content of 70 mgs./100 mls., but concentration of the juice provided a product which, on syruing, was well above the necessary minimum figure. The data indicates that about 16% of the A.A. in the combined juice and extract was lost during concentration. Large scale tests carried out in other experiments show that this loss was somewhat excessive, but it is probable that a 5—10% loss in A.A. may be expected during concentration carried out under normal conditions.

(b) Concentrated juice from fresh black currant pomace.

In August, 1942, 50 lb. of once-pressed pomace taken from a commercial syrup factory was extracted with 15 gallons previously boiled-out water, added at boiling point. Samples of extract were taken at intervals of 15 minutes for A.A. determinations. After $\frac{3}{4}$ hour, the pulp was pressed hard, and the extract strained and centrifuged. By this means 14 gallons extract and 32 lb. residual pomace were obtained. The extract was evaporated about $4\frac{1}{2}$ times and gave $3\frac{1}{4}$ gallons of concentrate with a gravity of 1.070.

The data is set out below.

	A.A. (mgs/100mls.)	Specific Gravity.	Acidity (as malic). %
Once pressed pomace ..	118.5	—	—
Extract after 15 minutes ..	35.3	—	—
" " 30 " ..	37.8	—	—
" " 45 " ..	41.7	1.016	—
Centrifuged extract	36.1	1.016	0.64%
Concentrate	106.0	1.070	2.80%
	(AA+DHA=170)		

If the A.A. figures and volumes for the centrifuged extract and concentrate are considered, it will be seen that there was a loss of 27% of A.A.

during the concentration, but the large difference between the figures for A.A. and A.A. + DHA. in the concentrate suggest that the concentration has been responsible for the conversion of part of the A.A. into the oxidised form and that the 27% apparent loss may not be due to complete destruction. The final figure of 106 mgs./100 mls. for the concentrate would allow for the production of a syrup with 70 mgs./100 mls. Although no syrup was actually prepared from this particular concentrate, other experiments have shown that the boiling method of extraction of pomace dissolves large quantities of tannins from the pomace and the syrups prepared from the concentrates are much too bitter for consumption as such. It would obviously be necessary to add the concentrate to the fresh juice and to syrup up the mixture in order to obtain a palatable product.

With regard to efficiency of extraction of A.A. from the pomace in this experiment, the extract, after centrifuging contained 85.3% of the total A.A. in the 50 lb. of pomace. The final concentrate, however, only retained 58.2% of the A.A. originally present in the pomace.

(c) *Concentrated syrups from fresh black currants.*

A series of syrups made from concentrated black currant juices were prepared in June 1942. 2 cwt. of Boskoop Giant fruit were milled and treated with 30.5 grs. Pectinol 10-M. for 16 hours. The first pressing yielded 11 gallons of juice and the second, after disintegration of the pomace, gave a further $2\frac{3}{4}$ gallons. The combined juices were $13\frac{3}{4}$ gallons (Juice I). The 59 lb. of residual pomace (Pomace I) left in the cloths was mixed with 9 gallons of water and boiled. The extract was sampled immediately and at various later times. On pressing, 8 gallons of liquor (Extract II) were collected and the final residue (Pomace II) weighed 39 lb.

Juice I was centrifuged and evaporated in the Kestner plant and the esters returned to the concentrate (Concentrate I: yield 5 gallons).

Extract II showed signs of fermentation overnight, but to reduce the high pectin content Pectinol 10.M. was added and allowed to work for a short period. The liquor was centrifuged and part of the clarified extract was concentrated. (Concentrate II.)

Various syrups were then prepared from Concentrates I and II separately, and the concentrates themselves were preserved, as shown below:—

Code.	Concentrate.	Strength of Syrup.	Method of Preservation.
1	I	55° Brix	450 p.p.m. Benzoic acid.
2	I	"	350 p.p.m. SO ₂ (as the sodium salt).
3	I	66° Brix	300 p.p.m. Benzoic acid.
4	I	"	350 p.p.m. SO ₂
5	II	58° Brix	"
6	I	not syrupe	600 p.p.m. Benzoic acid.
7	I	"	350 p.p.m. SO ₂
8	I	"	Pasteurisation on day after concentration.

The data for the various juices, syrups and concentrates immediately they were prepared is given in Table IV.

TABLE IV.

ANALYTICAL DATA FOR EXPERIMENTAL JUICES, CONCENTRATES AND SYRUPS.

Sample.	Specific Gravity.	Acidity as % citric. w/v.	Ascorbic acid. mgs/100mls.	Total ascorbic acid. (AA.+DHA)
Milled fresh fruit	—	—	174.0	180.0
Fresh juice	—	—	178.0	187.0
Depectinised juice I* ..	1.054	3.45	175.0	186.5
Pomace I	—	—	116.0	127.0
Extract II†	1.027	1.22	54.0	69.0
Pomace II	—	—	34.0	47.0
Concentrate I	1.117	7.8	343.0	396.0
Concentrate II	1.168	10.03	372.0	397.0
Syrup 1 & 2 55° Brix ..	1.260	—	202.0	280.0
Syrup 3 & 4 66° Brix ..	1.325	—	169.0	197.0
Syrup 5 55° Brix	1.279	6.53	191.0	217.0

* Calcium pectate = 0.216%

† " " = 0.639%

The stabilised syrups and concentrates were examined after $4\frac{1}{2}$ and 6 months' storage period, and the results are given in Table V.

TABLE V.

Code.	Sample.	Original AA mgs 100	Analysis AA + DHA mgs 100	Storage for $4\frac{1}{2}$ months. mgs 100 AA	Storage for 6 months.		Loss of AA after 6 months %	Loss of AA + DHA after 6 months. %
					AA mgs 100	AA + DHA mgs 100		
1	55° B. syrup + benzoic acid ..	202.0	280.0	172.7	169.7	182.3	16	34.9
2	55° B. syrup + SO ₂	202.0	280.0	181.6	171.0	192.3	15.4	31.4
3	66° B. syrup + Benzoic acid	169.0	197.0	173.3	170.0	179.3	-0.6	9
4	66° B. syrup + SO ₂	169.0	197.0	143.0	125.0	143.5	26	27.2
5	58° B.* syrup + SO ₂	191.0	217.0	109.0	96.2	121.3	49.5	44
6	Concentrate I + Benzoic acid	343.0	396.0	327.0	307.2	319.2	10.5	19.4
7	Concentrate I + SO ₂	343.0	396.0	339.5	327.5	341.2	4.5	13.8
8	Concentrate I pasteurised	343.0	396.0	288.0	250.0	262.7	27	33.7

* $\frac{1}{2}$ gallon stored in gallon jar.

Certain interesting features in Tables IV and V may be mentioned.

(a) The DHA. figures for juices, syrups and concentrates in course of production show widely differing values. For example, the fresh juice con-

tained 9 mgs., depectinised juice after 16 hours' exposure to air 11.5 mgs., once-pressed pomace 11 mgs., boiled extract from pomace 15 mgs., twice-pressed pomace 12 mgs., concentrated juices 53 and 25 mgs., and syrups 78, 28 and 26 mgs. respectively (Table IV). There seems to be no definite correlation between any obvious factor, such as exposure to air and the formation of the dehydroascorbic acid. A decrease in the A.A. figure can either be accounted for by a change into DHA. or an irreversibly oxidised form, but a loss of total ascorbic acid (*i.e.* A.A. + DHA.) can only be caused by the irreversible changes.

(b) Storage tests over a 6-month period indicate one clear correlation between losses of A.A. as compared with losses of DHA. In every case except Table V, No. 5 (which is invalidated on account of the unsatisfactory nature of the storage conditions) the loss of total ascorbic acid is greater than the loss of A.A. alone. Apart from this the respective figures for A.A. and DHA. vary considerably. The effect of sodium benzoate compared with SO_2 on the vitamin C values of syrups and concentrates shows that there was a slight advantage in the use of SO_2 in the 55°B syrup and the Concentrate I, but the benzoate had a better effect in the 66°B. syrup. Pasteurisation was responsible for a heavy loss in A.A. and DHA. in Concentrate I. (The gain in A.A. shown in Sample 3 is within the range of experimental error.)

The experiments indicate that it should be possible to produce black currant syrup with A.A. figures over 150 mgs./100 mls., which is approximately double the normal figure for a straight syrup made from pure, concentrated juice. The flavours of the syrups were remarkable for their luscious character and the intensity and freshness of the fruit character. The only criticism concerned the acidity which was considerably higher than in the normal type of syrup.

Such syrups as these with higher ascorbic acid contents would save in the use of sugar, and there would be a considerable saving in the provision of bottles and cases for transport.

Summary.

1. Optimum conditions for the extraction of residual ascorbic acid from once or twice pressed black currant pomace have been determined.
2. The production of syrups with high vitamin C contents from concentrated, fresh black currant juice is described and the stability of the products over a 6-month period is given.

THE COLD SO₂ METHOD OF PLUM PRESERVATION.

A LARGE EXPERIMENTAL TRIAL IN KENT.

By V. L. S. CHARLEY, L. F. BURROUGHS and A. POLLARD.

During the early summer of 1942 the possibility of such a large crop of plums maturing in Kent that difficulties would be encountered in disposing of the fruit in a satisfactory manner became apparent. Consequently arrangements were made by the Ministry of Food to extend the pulping facilities in the county and the co-operation of the Long Ashton Research Station was sought with regard to the technical supervision of a large scale experimental scheme for preservation of plums by the Long Ashton cold process.

A detailed report has already been submitted to the Ministry of Food. The present contribution contains general technical details which indicate that, provided sound storage vessels are available, the cold process gives satisfactory results on a large scale. The different subjects concerned are dealt with separately, the various paragraphs being condensed from the official report.

1. The Preserving Vessels.

The majority of the vessels were made by placing 2, 3 or 4 three-foot circular sections of concrete piping on top of each other, specially prepared joints being connected together by various means. The methods of forming a suitable foundation, of erecting the sections and jointing them together, developed as experience was gained, but the earlier batteries of tanks gave considerable trouble with leakage both through the base, the joints and even through the material of the concrete itself. The last two sites were erected with the help of the experience gained elsewhere, and the tanks proved to be quite sound and satisfactory in every way.

The pipes varied in diameter from 4' 6" to 6'. A tank 6' in diameter and 12' deep held 2,100 gallons, and such a vessel could be filled with 6—6½ tons of plums.

2. Linings.

The presence in the preserving liquor of SO₂ and the natural fruit acids in the plums made it essential to provide an inert, tasteless lining to cover the concrete and protect it. Two linings were chosen as a result of previous experience and information from various firms. Both materials had a basis of bitumen, one being applied in a slightly diluted form by hand brushing, the other being sprayed on in the form of a solution in an organic solvent. Both materials formed a hard, black, glossy surface on the concrete and on tanks which had been structurally well built the linings remained intact and prevented contact between the liquor and the concrete. Where tanks were not structurally sound, leakage occurred and the linings were apt to disintegrate and loosen from the concrete in large patches.

No trace of undesirable taste due to either of the linings could be detected

in jams made from preserved plums, although one sample was very badly discoloured with the lining material.

3. Lids.

Double thickness, wooden lids were used with a layer of tarred paper in between; $\frac{1}{2}$ " timber lids warped badly but 1" wooden lids did not suffer from this defect. At one site concrete lids were used but their weight was such that a crane was needed to hoist them to the top of the tanks.

4. Sealing the Lids.

It was desirable to seal the lids down as soon as possible after filling the tanks, to prevent loss of SO_2 gas. Owing to difficulties of ensuring that the tanks were water-tight this was not possible in many cases until after 2 or 3 weeks, as it was necessary to wait to see whether leakages would occur. The final sealing down was effected by using mixtures of pitch and one of the lining materials, or a special form of "sealing putty," which softened under the application of heat and set to a firm seal when cold. This material was difficult to apply to the tall 12' tanks, but on shorter tanks its application proved to be easier and the results were satisfactory. A layer of pitch about $\frac{3}{4}$ " deep was run over the entire tops of the tanks in an attempt to prevent evaporation through the lids. During the period, September 1942–February 1943, the weather was very mild and no sign of the pitch cracking was noticed.

5. Filling the Tanks.

The final procedure adopted was as follows:—

- (i) Water was filled into each tank to the calculated depth from a hose pipe.
- (ii) The required amount of 6% SO_2 was added to the water.
- (iii) The plums were tipped into tanks until the level of the liquor rose to about 3" from the top.

The violent churning of the liquor caused by the plums being tipped from a height of some feet was considered sufficient to mix the 6% SO_2 into the water.

6. Strength of SO_2 Solution.

The earlier work at Long Ashton had shown that under good conditions of storage, a liquor originally containing 1000 p.p.m. SO_2 was capable of preserving the plums over a period of many months. It was realised that many additional losses of SO_2 would occur at the Kent site and the theoretical strength of the preserving solution was raised to 1500 p.p.m. at the commencement of the experiment. However, leakages from some of the tanks lowered the SO_2 content to such an extent that slight surface fermentation occurred. At that stage of the experiment insufficient experience was available to decide how far the original content of SO_2 was responsible, and as it was obviously desirable to save the plums, the SO_2 strength was raised to 2000 and later still to 3000 p.p.m. In the opinion of the writers, these increases were necessary mainly on account of the leakages in the tanks, and that if these had not occurred an actual figure of 1500 p.p.m. SO_2 in the preserving liquor immediately after adding the plums would suffice.

During the early part of the experiment, it was necessary to determine what approximate losses occurred during the making up of the preserving liquor in the tank and during the addition of the plums. Table I gives the data on this point.

TABLE I.
LOSS OF SO_2 IN FILLING OPERATION.

Tank No.	Theoretical strength of diluted liquor calculated on amount of 6% SO_2 added.	Actual SO_2 in liquor found by titration after mixing 6% SO_2 with water in Tank, but before adding plums.	Actual SO_2 in liquor during (1) or immediately after (2) filling tank with plums.
1	3,000 p.p.m.	—	1,900 (2)
2	"	—	2,750 (1)
3	2,000	—	1,600 (1)
4	"	—	1,500 (2)
5	3,000	2,440	—
6	"	2,150	2,000 (1)
7	"	"	2,240 (1)
8	"	2,400	2,040 (2)
9	2,000	—	1,470 (1)

The losses varied between 500 and 1000 p.p.m. SO_2 , each foreman having his own technique for filling. These figures suggested that if it was desired to commence the preservation process by having the plums immersed in a solution containing at least 1500 p.p.m. it would be necessary to calculate the addition of 6% SO_2 on the basis of 2500 p.p.m. in the original liquor. This calculation presupposes that losses due to leakage would be negligible.

7. Method of Sampling from Tanks.

The criterion adopted at Long Ashton to decide whether any given bulk of plums was in danger of fermenting was to determine the SO_2 content of the liquor; if the figure was above 300 p.p.m. then it was felt that the plums were still safe, but if the figure was below 300 p.p.m. fermentation was considered a definite possibility. The liquor from the sealed tanks at the Kent sites was consequently examined from time to time. It was found by experiment that it was not possible to get figures representing the bulk of the liquor unless it was sampled below a depth of 2' from the surface. Where possible, samples were taken from a depth of 4' below the surface.

8. Condition of the Fruit.

The fruit ranged from very immature fruit (Monarch) to soft, over-ripe plums, showing in some cases a considerable admixture of fruit suffering from brown rot. Such soft fruit did not seem to present any special difficulties with regard to preservation, but the hard Monarchs developed a slight toughening of the skin after contact with SO_2 .

9. Cases of Fermentation in Fruit or Liquor.

The following comprise all the cases of fermentation during the experiment :

(a) At one site, the leakage was so bad in two tanks that the level of the liquor could not be kept above the plums. The fruit consequently fermented and became a total loss.

(b) A few bushels of plums were skimmed off some tanks at another site due to surface fermentation. The bulk of the plums was unaffected. The fruit lost in (a) and (b) represents the only loss in the whole experiment.*

(c) Four cases of fermentation in the liquor were noted. These were all in tanks that were leaking, and as SO_2 was regularly added in such cases, it is not possible to discover any real correlation between SO_2 content and incidence of fermentation. Addition of further SO_2 stabilised the position.

10. SO_2 Changes in Preserving Liquor in Tanks.

In 44 tanks no SO_2 was added after the initial filling treatment. These tanks have been those which have kept in a sound condition for several months. Some time after sealing down the lids the SO_2 content of the liquor varied between 550—750 p.p.m., whilst the figures for the liquor from unsound tanks varied between 300—600 p.p.m.

11. Jam Making Tests on Preserved Plums.

Three tests were carried out at Long Ashton in November 1942 on the suitability of the plums from the Kent sites for jam-making.

(i) Some Czar plums, showing obvious signs of fermentation, were chosen to represent the very poorest quality fruit that was, at that time, in any of the tanks. The fruit was so badly disintegrated that separate SO_2 figures for fruit and liquor could not be obtained. The mixed material, however, contained 403 p.p.m. SO_2 and the final jam retained 38 p.p.m., just slightly below the legal limit of 40 p.p.m. The jam had a poor set, but a fair flavour—rather spoilt by a slight but definite fermentation taste.

(ii) For the second test, some Belle de Louvain plums in perfect condition were chosen. The liquor contained 2240 p.p.m. SO_2 and the fruit 2210 p.p.m. (these high figures were due to the fact that an additional volume of 6% SO_2 had been added to the tank shortly before the samples for jam-making were taken). The jam retained only 28 p.p.m. of SO_2 and the flavour was full, rich and free from any taint.

(iii) Lastly, the immature Monarch plums previously mentioned were sampled and converted into jam. In this case the fruit was very badly contaminated with some of the lining material which had peeled off the tank. The sample was quite black. The plums contained 560 p.p.m. SO_2 and the liquor 607 p.p.m., the jam retaining only 28 p.p.m. The set was good, the colour was an abnormal dark green, the skins were slightly toughened but no taste attributable to the lining was noticed.

12. Conclusions.

(i) The Long Ashton cold process was satisfactorily applied to the preservation of 398 tons of plums and, apart from $11\frac{1}{2}$ tons that were lost by fermentation, no other losses occurred. This represents a loss of under 3%.

(ii) Plums taken from tanks that commenced to leak in February and April, 1943, were still in perfectly sound condition.

* In April 1943, a tank of Damsons was lost on account of fermentation. In this case the acidity of the liquor was almost completely neutralised by contact with the concrete. Crystals of acid calcium malate were found inside, on the tank wall.

Summary.

An account is given of the technical details of an experiment in which 398 tons of plums were preserved in Kent during the heavy plum crop of 1942. Details are given showing that the Long Ashton cold process was satisfactorily applied on a large scale at short notice, thus enabling a considerable tonnage of plums to be saved from wastage.

Details of SO_2 strengths and losses are given, as well as the results of some jam-making tests.

Acknowledgment.

The writers wish to express their appreciation of the action of the Ministry of Food in allowing them to publish this brief report on the experiment.

A NOTE ON THE PRODUCTION OF A CONCENTRATED SYRUP FROM TABLE BEET.

By VERNON L. S. CHARLEY, M. E. KIESER and A. POLLARD.

In the course of the general work of the Fruit Products Section on the utilization of surplus and low grade fruit and vegetables a small experiment was carried out on table beet in which the method evolved for the treatment of surplus carrots was applied to this vegetable.

196 lb. of globe beet grown in the Long Ashton plantations were procured on November 15th, 1942. The roots were washed free from soil and were milled in the standard type of grater cider mill. No difficulties were encountered and the roots were disintegrated into an extremely fine pulp in which there were practically no large pieces of tissue.

The pulp was placed in cloths and built up into the normal form of "cheese" with wooden racks, and the juice was pressed out under a maximum pressure on the ram of 2,000 lb. per square inch. The juice ran away from the pulp very freely and one pressing was sufficient to express the equivalent of 157 gallons of juice per ton of beet. The residual tissue was compact and could be readily disengaged from the cloths.

The fresh juice possessed a specific gravity of 1.049, which figure is practically identical with that for an average apple juice. The juice was intensely coloured and it was felt that this colour, especially in its concentrated form in the evaporated product, would be a drawback to commercial use and an attempt was made to remove a proportion of the colour by the use of decolorising carbon. 4 lb. 2 oz. of a special carbon for sugar clarification was added to the juice which had previously been simmered in a stainless steel pan for 10 minutes to coagulate various organic constituents which formed as a scum on the surface. The scum was removed and the treatment with carbon was commenced at 85°C and continued as the juice gradually cooled overnight.

Simple filtration through two layers of muslin was sufficient to give a light orange coloured liquor which was practically clear. The decoloration was remarkably effective but the amount of carbon used was considerably greater than that normally used for sugar materials. A final clarification to remove finely divided particles was achieved by the use of an Alfa Laval centrifuge. The analysis of the juice after centrifuging was as follows:—

Specific gravity	..	..	..	1.047
Acidity (as malic acid)	..	..	..	0.12%
pH	..	..	..	5.43
Sugars: Invert	..	..	..	0.4%
Sucrose	..	..	..	8.2%

The clear juice was evaporated under a vacuum of 27"—28" in a Kestner climbing film, triple circulation evaporator installed at the Research Station for experimental purposes and no trouble whatever was encountered during the process. There was no tendency to gel in the final tubes and concentration was taken to a gravity of 1.210 in one sample and 1.290 in another. High concentrations could not be achieved in the pilot plant on account of the small

volume of juice available, and the concentrate produced was taken down to a much smaller volume in an ordinary laboratory vacuum apparatus. The analysis of the final product is given below :—

Specific gravity	..	..	..	1.378
Acidity (as malic)	..	..	..	0.75%
pH	..	..	..	5.20
Sugars : Invert	..	..	..	3.0%
Sucrose	..	..	..	49.4%

The concentrated syrup has shown satisfactory keeping properties over a period of 3 months and at a gravity of 1.378 has retained its full fluidity. There is a very slight taste of a vegetable character, but the predominating flavour is a cloying sweetness and the vegetable taste would be completely masked if the syrup was blended with any other foodstuff.

The concentrate exhibited the phenomenon of dichromatism, being a clear red colour in direct light but green when viewed in reflected light, the appearance being similar to lubricating oil. The diluted concentrate was bright red and did not show the green colour in reflected light.

EXPERIMENTS ON THE DOMESTIC EXTRACTION OF SUGAR FROM SUGAR BEET.

By ALICE CRANG and D. PEARCE JONES.

Introduction.

The increased knowledge of the value of the sugar beet crop and the strict rationing of sugar have encouraged a number of people to grow sugar beet in gardens or allotments for private use. This has been officially discouraged, as it was realized that the extraction processes in use were only suited to the production of sugar on a commercial scale. However, the demand for a domestic method of extraction has been so great that the following experiments were carried out to see whether a palatable syrup could be extracted in the home at all economically, or whether alternative methods of utilising the beet as a sweetening agent could be suggested.

Source and Sugar Content of the Beet.

The sugar beet used in these experiments was grown from seed at this Research Station. The sugar content found in the freshly pulled roots at the end of September, November and December was respectively 13.1%, 14.3% and 16.5% (as sucrose). In no case was any reducing sugar found in the fresh roots. The sugar content increased when the roots were lifted and left on the ground for a week before extraction.

Extraction of the Sugar.

The tops were removed, the roots scrubbed in cold water and thinly peeled. The roots were sliced thinly on a marmalade shredder to facilitate diffusion of the sugar.

The rapid discolouration of the cut surfaces of the beet when exposed to the air for even a few minutes was overcome by placing the beet prepared for slicing in boiling water which was used in the subsequent extraction. The beet was then sliced directly into boiling water contained in the pan in which the extraction was to be carried out and the water in which the beets had been soaking added to it. In this way discolouration of the beet was prevented and no loss of sugar occurred. In an earlier test in which the peeled beet was placed in cold water before slicing and the water subsequently discarded, it was found that a loss of 1.3% of the available sugar occurred from the soaking.

The total quantity of water used in the extraction was $1\frac{1}{2}$ gallons of water for every 4 lb. of prepared beet, two extractions being made. In the first extraction 1 gallon was used (half this quantity being used also for soaking the beet before slicing) and $\frac{1}{2}$ gallon in the second.

In the first experiments the sliced beet was placed in cold water which was then brought to the boil, but it was found that when the beet was placed in boiling water instead of cold, a better yield of sugar in the extract was obtained. Thus in ensuing experiments the latter procedure was adopted.

The amounts of sugar extracted using hot and cold water to begin the extraction were as follows :—

Sugar extracted using cold water initially 11.9% (as sucrose).

„ „ „ boiling water „ 13.4%

Sugar content of the beet 15.0% (as sucrose).

Each extraction was carried out by boiling the beet for 40 minutes in a covered aluminium saucepan. After the first extraction the liquid was strained off and the beet residue returned to the saucepan while still hot. After the second extraction the residue was squeezed through muslin to obtain as much extract as would be possible at home without special equipment.

Clarification and Concentration of the Extract.

When the extract was concentrated without any clarification the product obtained was very dark in colour with a rather unpleasant “earthy” flavour. Straining through a felt jelly bag did not remove this.

Two methods of clarification were tried, the first using precipitated chalk and the second using activated charcoal and filter cell (diatomaceous earth).

(1) To every 3 gallons of total extract one level teaspoonful of precipitated chalk was added, and the whole extract evaporated to half its volume in a preserving pan. It was then poured through a felt jelly bag, the last trace of sugar being washed through with $\frac{1}{2}$ pint of hot water. Concentration was continued in a smaller pan until the syrup showed a content of 75–80% soluble solids when tested by a hand refractometer, at which stage it was the consistency of treacle.

By this method 8 lb. beet produced 25.5 oz. of a moderately clear, dark brown concentrate of a definitely sweet but earthy flavour, with a soluble solids content of 79.6% and an ash content of 3.63%.

(2) Approximately 3 gallons of combined extract was evaporated to about 1 gallon. One level tablespoonful of activated charcoal was added and the whole boiled for 40 minutes, when one level tablespoonful of filter cell was added and boiling continued for 20 minutes. Two tablespoonfuls of filter cell were spread over the moistened inner surface of a felt jelly bag to form a lining in the cone, the hot extract was poured in and allowed to drip over night, the last traces of sugar being washed through with $\frac{1}{2}$ pint of hot water, and the filtered extract concentrated to 75–80% soluble solids content as in (1).

By this method 8 lb. beet produced 24.5 oz. of a concentrate, lighter in colour and clearer than that produced by method (1) and of a much better flavour, with soluble solids content of 80.1% and ash 3.65%.

Cost of Extraction.

It was estimated that for the preparation of a syrup of 75–80% soluble solids content, from 8 lb. of prepared sugar beet (using either method of clarification) an average of 200 cu. ft. of gas was used, at an average cost of 10d. for the whole process. A gas cooker of the Radiation “Bungalow” type was used throughout, and the above estimations were based on 25 cu. ft. of gas, costing $1\frac{1}{4}$ d., being used per hour by a single burner when full on. The estimate allows for the use of two pans for the first $2\frac{1}{4}$ hours’ reduction of the

extract, *i.e.* from 24 pt. to about 12 pt. The pans used for this were aluminium preserving pans of 2 gallons capacity and internal diameter 1 ft.

Results of Syrup Preparation.

About nine-tenths of the sugar from the sugar beet was extracted domestically by the addition of boiling water to the sliced beet, and boiling for two periods of 40 minutes each, the water used being in the proportion of 1 gallon to 4 lb. beet for the first extraction.

The combined extracts were clarified to some extent by boiling with precipitated chalk (1 level teaspoonful to 3 gallons extract), followed by straining through a felt jelly bag. A higher degree of clarification and some decolouration was obtained by boiling with activated charcoal (1 level tablespoonful to 3 gallons extract), and removal of this by addition of an equal amount of filter cell followed by filtering through a jelly bag coated inside with filter cell. Some of the earthy flavour was also removed by this process, and the resulting syrup was not unpleasant.

Nevertheless the process is of necessity somewhat tedious and wasteful of fuel. From 8 lb. of prepared beet a maximum of 26 oz. (about 1 pint) of syrup of 80% soluble solids content is obtained, for the use of 200 cu. ft. gas. A weaker syrup may be made, but this would have to be bottled in airtight jars and pasteurised to prevent fermentation, unless it were used within a day or so.

The Drying of Sugar Beet.

Attempts were made to dry sugar beet in both sliced and shredded form, but in all cases the products obtained were unsatisfactory, particularly as regards colour. The results of these trials are tabulated below:—

Initial wt. (Prepared).	Treatment.	Dry wt.	Temp. of Drying °F.	Time of Drying.	Results.
<i>Sliced Beet.</i> 1a. 1 lb.	None	3½ oz.	190	18 hrs.	Product crisp when removed from oven, but becoming pliable after a few hours. Slices varied in colour from white to black.
b. 1 lb.	Placed 10 mins. in salt solution (1½ oz./gal.) before drying.	3½ oz.	190	20 hrs.	As a, but colour slightly better though still dark.
2a. 1 lb.	None	3½ oz.	300 200	for 1st hr. following 6 hrs.	Similar to 1.
b. 1 lb.	Placed 10 mins. in salt solution (1½ oz./gal.) before drying.	3½ oz.	300 200	for 1st hr. following 8 hrs.	Colour slightly better than 2a, but still dark.
<i>Shredded Beet.</i> 3a. 1½ lb.	None	4 oz.	350 200	for 1st hr. following 4 hrs.	Crisp product becoming pliable. Colour dark grey.
b. 1½ lb.	Placed 10 mins. in salt solution (1½ oz./gal.) before drying.	4 oz.	350 200	for 1st hr. following 6 hrs.	As 3a, but colour slightly better though still grey.

These tests were made with the idea that the dried sliced beet might be

broken up and used as a coarse sweetened "meal" for the making of biscuits, etc. Alternatively it was thought that the dried shredded beet could be used in place of desiccated coconut. The poor colour of the product, however, proved a very great disadvantage, and other methods of preventing discolouration were considered too complicated to be practicable domestically and were therefore not tested.

Results of Drying.

No satisfactory method of drying sugar beet was found. In all methods tested the colour of the final product was very poor, though a slight improvement was noted when the beet was allowed to stand in a 1.5% salt solution for 10 minutes before drying, and when drying was rapid and the initial temperature used was high.

The Use of the Sugar Beet in Chutney.

(a) *Sliced Root.* It was thought that a simple way of utilising small amounts of sugar beet grown domestically would be to use the minced beet as an ingredient in chutney, partly or wholly replacing the sugar normally required by the recipe.

Apple and green tomato chutneys were prepared, replacing half the sugar in the recipe by an equivalent amount of sugar in the form of the minced beet; marrow chutneys were also made replacing two-thirds and the whole of the sugar respectively by sugar beet.

In each case the chutney with sugar beet was decidedly inferior in flavour and consistency to the chutney from the similar recipe but using sugar. The sugar beet did not seem to soften sufficiently to blend with the other ingredients, but gave the chutney a dry, rough consistency.

(b) *The Extracted Syrup.* A syrup extract of 80% sugar content was tried in chutney in place of sugar. The syrup had been clarified by method 1 (see above), and was used in the proportion of 10 parts of syrup *vice* 8 parts of sugar.

The resulting chutney was of very good colour, flavour and consistency. The flavour of the syrup was masked by the spices and vinegar in the chutney.

Comparison of Minced Sugar Beet and Sugar Beet Syrup in Chutney.

The samples of chutney prepared using the minced root were all below the standard of chutney made from similar recipes without the sugar beet. The colour was on the whole poor, and the consistency dry and rough, though in some cases the flavour was fairly good. All tasted sufficiently sweet and they have kept satisfactorily.

The syrup was used most successfully in place of sugar in chutney, 10 parts of a syrup containing 80% sugar replacing 8 parts of pure sugar. The chutney so prepared was well up to standard in every respect.

Summary.

1. In experiments on the use of domestic methods of extraction of sugar from sugar beet, it was found that a satisfactory proportion of the sugar could be extracted, but the process is tedious and wasteful of fuel.

2. If the extract is not clarified, or only clarified with precipitated chalk before concentration, the flavour of the product is rather unpleasant. This flavour is not noticeable when the syrup is used in chutneys.

3. Clarification with charcoal and diatomaceous earth is more complicated than with precipitated chalk, but the process could be carried out domestically with care. A dark coloured syrup is obtained which could be used instead of treacle for many purposes.

4. Drying the roots cannot be recommended as a method of utilising the beet domestically.

5. The use of minced sugar beet in chutney cannot be recommended, but the sugar beet syrup may well replace sugar in chutneys.

A COMPARISON OF THE ASCORBIC ACID CONTENT OF STORED PEAS, BEANS AND PARSLEY DRIED BY VARIOUS DOMESTIC METHODS.

By ALICE CRANG, M. JONES, D. PEARCE JONES and M. STURDY.

Until recently it has been assumed that dried vegetables contained little or no ascorbic acid (Vitamin C), but the recent industrial methods of dehydration and subsequent storage in inert gases have yielded products containing considerable amounts. The following tests were carried out to see whether different methods of drying and storage which could be used domestically gave significant differences in the value of the dried products. Peas and beans were selected as the vegetables most frequently dried at home and parsley as a culinary herb commonly used in the dried state.

The variations of treatment included :—

- (a) Methods of blanching.
- (b) Conditions of drying.
- (c) Methods of covering before storage.

In addition comparisons were made with beans preserved in salt.

Cooking tests were carried out on peas and beans and the colour and flavour assessed in the dried parsley after the period of storage.

These tests were necessarily of a preliminary character, but the results do show that the Vitamin C content of the stored product is affected considerably by the method of blanching used as well as by the method of covering the containers. The peas dried under heat retained more Vitamin C than those dried in the air. The loss of Vitamin C in beans and parsley was considerable in each test. Dried beans were generally inferior to similar beans stored in salt.

EXPERIMENTAL.

A. Peas and Beans.

Materials and Methods.

Two varieties of peas were used in the drying tests: "Onward," which were in excellent condition when used, and "Harrison's Glory," which were, unfortunately, rather too mature. Several batches of runner beans of unknown variety were used. In each case the beans were sliced on a bean slicer immediately before blanching.

(a) *Blanching Treatments.* Blanching, or cooking in boiling water or steam for a short period, is recognised as essential in the preparation of most dried vegetables of good quality, but unless care is taken at this stage, considerable loss of the soluble constituents may occur through leaching.

Variations of blanching treatments used included :—

- (i) Blanching in fresh boiling water for each batch.
- (ii) Using the same boiling water for 6 consecutive batches of the same vegetable, *i.e.* serial blanching.

- (iii) Adding sodium metabisulphite to give 1000 p.p.m. of sulphur dioxide in the blanching water, and using this for 6 consecutive batches of vegetables*.
- (iv) Blanching in steam for 1 minute.
- (v) do. 3 minutes.

(b) *Drying.* Three types of drier were used :—

- (i) A domestic gas oven.
- (ii) A specially constructed drier of wooden framework and card-board sides fitted with wire trays, the drier being placed over a gas ring with an asbestos mat on top to give uniform heat. The drier was constructed following details supplied by B. M. McLellan.
- (iii) A steam-heated laboratory oven. As the particular oven used was made of copper, trays to fit it were made of wire netting covered with butter muslin.

In no case was any attempt made to remove the steam by vacuum, as this would not be possible in the home, but the laboratory oven doors were left slightly open to allow steam to escape. It was thought that this method resembled conditions using a hot water cistern, often used for drying fruit or vegetables in the home.

The temperatures used for drying are given in each case.

(iv) Peas were also dried in the air without previous blanching.

(c) *Covering and Storage.* It is realized that storage in the air necessarily causes loss of ascorbic acid and flavour in dried products. An attempt was made to prevent this to some extent by heating the dried vegetables in metal-topped preserving jars, which on cooling formed air-tight closure before storage. In several instances the jars had a slight vacuum when they were opened for testing, but this was always too small to be registered on a vacuum gauge.

Other products were stored in glass jars covered with parchment or cellophane covers.

In all experiments the jars were stored in a dark cupboard alongside one another, to avoid variations of humidity or temperature affecting the results.

Analytical Methods.

Total Solids. The total solids were determined on the fresh and dried products in each test, so that the amount of ascorbic acid retained could be calculated.

Ascorbic Acid. The ascorbic acid content of the dried peas was determined on the products after grinding in a coffee mill, since higher values were obtained in this way than if milling was omitted. This was followed immediately by the usual extraction with sand and metaphosphoric acid. The fresh peas and the fresh and dried beans were not milled before extracting the ascorbic acid.

* Dr. J. Barker, Low Temperature Research Station, Cambridge, found 600 p.p.m. SO_2 and slightly alkaline conditions most satisfactory.—Private communication.

Results.

(a) *Blanching.*

Serial Blanching. Six batches each containing 1 lb. of shelled peas were blanched in $1\frac{1}{2}$ pints of boiling water for 1 minute, followed by $\frac{1}{4}$ minute in cold water, using the same blanching water throughout, making up the volume and reboiling before each batch of peas was added.

The peas were dried in the steam oven at temperatures of 110° — 150° F. until dry. Batches 1, 2 and 6 were stored in glass jars covered with parchment and batches 3, 4 and 5 in metal topped jars. The total solids after storage ranged from 89.1 to 90.3%.

TABLE I.
SERIAL BLANCHING OF PEAS.

Batch.	Ascorbic Acid.			
	Freshly Dried Material.		After $3\frac{1}{2}$ Month's Storage.	
	mg./100g. Fresh Weight.	% Retained.	mg./100g. Fresh Weight.	% Retained.
1 & 2 (Average) ..	17.1	72.6	6.2	26.4
3 & 4 „ ..	17.6	74.5	6.9	29.4
5	19.1	81.3	8.8	37.2
6	20.6	87.5	10.6	45.1

These figures clearly show the higher retention of Vitamin C in the peas when blanching water has been used for several previous batches.

The beneficial effects of using the same blanching water for successive batches of beans is shown in the following series in which six lots of 1 lb. of sliced beans were blanched in 3 quarts of boiling water for 1 minute each, followed by $\frac{1}{4}$ minute in cold water. The total solids and ascorbic acid were determined immediately after blanching.

TABLE II.
SERIAL BLANCHING OF BEANS.

Batch.	Ascorbic Acid.	
	Mg./100g. Fresh Weight.	% Retained.
1	2.14	22.6
2	3.27	34.5
3	3.87	40.9
4	3.95	41.7
5	4.08	43.1
6	4.30	45.4
Fresh Beans	9.47	—

Addition of Sodium Metabisulphite to Blanching Water. Sodium metabisulphite was added to the boiling water to give 1000 p.p.m. of SO_2 in the water. 1 lb. lots of beans were again blanched for 1 minute in 3 quarts of water followed by cooling for $\frac{1}{4}$ minute in cold water. The results compared with other methods of blanching are given in Table III.

Steam Blanching. (1) 1 lb. batches of sliced beans were placed in a blanching basket in a container suspended just above the boiling water and steamed for 1 minute. The heat penetration was poor and the beans in the centre were still cool after this time.

(2) $\frac{1}{2}$ lb. batches of sliced beans were steamed as above for 3 minutes, by which time all the beans appeared sufficiently blanched.

In the results given below, after various methods of blanching the beans were dried in a steam oven at 140°F . until crisp, then placed in metal-topped preserving jars and heated in an oven at 230°F . for 30 minutes and stored for $3\frac{1}{2}$ months in the dark before testing.

TABLE III.
COMPARISON OF METHODS OF BLANCHING BEANS.

Method of Blanching.	Total Solids %		Ascorbic Acid Content.		
	Before Blanching.	After Storage.	Before Blanching.	After Storage.	% Retained.
1 min. in boiling water ..	7.51	85.24	mg./100g. 9.47	mg./100g. 21.13	19.7
1 min. in boiling water containing 1000 p.p.m. SO_2	6.91	85.15	4.33	18.95	35.5
1 min. in steam	8.09	84.80	10.46	11.93	10.9
3 min. in steam	8.23	88.84	14.47	19.26	16.8

It is unfortunate that the fresh beans used varied so greatly in ascorbic acid content. The results suggest that the sulphur dioxide in the blanching water has a beneficial effect in retaining the Vitamin C, whereas insufficient steam blanching results in large losses.

(b) Conditions of Drying.

Peas. The time required to dry the blanched peas in the specially constructed drier averaged 9 hours with the temperature kept as near as possible to 140°F ., the range being from 110° to 150°F .

Similar peas dried in a steam oven, in which the ventilation was not so good, required 21 hours at temperatures of 120° — 140°F . In the tests peas were blanched for 1 minute in boiling water.

Other peas from the same deliveries were allowed to dry, without any preliminary blanching, at room temperature. One lot was shelled before drying and two others were left in the pod for two months before shelling. The results of Vitamin C retention and cooking tests are given in Table IV.

TABLE IV.
COMPARISON OF METHODS OF DRYING PEAS.

Variety.	Conditions of Drying.	Ascorbic Acid % Retained.		Cooking Tests After Storage.		
		Freshly Dried Peas.	After 3½ Months.	Colour.	Texture.	Flavour.
Onward ..	Blanched ; dried in domestic drier at 130—150°F.	72.6	26.4	Green	Soft	Fairly good. Best of the Series
do. ..	Peas in pod dried in the air for 2 months	—	11.9	Yellow-green	Very hard	Poor
Harrison's Glory ..	Blanched ; dried in steam oven at 120—140°	55.5	—	Light green-grey	Hard	Fair
do. ..	Blanched ; dried in domestic drier at 110—150°	71.4	56.2	Yellow-green	Hard	Poor
do. ..	Peas in pod dried in the air for 2 months	—	14.4	Yellow-green	Fairly soft	Poor. Typical "packet pea" flavour
do. ..	Peas shelled ; dried in air for 2 months	—	7.5	Yellow-green	do.	do.

In each experiment the treated peas were stored in glass jars covered with parchment.

The results show the much greater loss in Vitamin C of the peas allowed to dry in the air and considerable variation in the cooking quality.

Beans. In one series the beans, after blanching, were divided, one half being dried for 7 hours in the domestic drier at 110°–150° and the other half for 15 hours at 140°F. in a steam oven. In spite of the longer time required for drying the beans in the steam oven, after storage under similar conditions, the ascorbic acid content showed no significant difference, being 19.0 and 19.1 mg./100 g. of the dried beans in the two cases.

The total solids of the beans after storage varied from 85 to 87%.

(c) *The Effect of the Covers.* The method employed in attempts to remove as much air as possible in the storage container was as follows:—The preserving jars fitted with lids and containing the freshly dried materials were placed in an oven for 35 to 40 minutes at 200 to 230°F. The lids were held in place by the spring clips while the jars cooled, after which the vacuum thus created was sufficient to hold the lid in position during storage. A drawback of the method was that it necessitated a further heating of the vegetables and care was needed to prevent scorching.

In each of these tests the dried products were divided, part being treated as above and the remainder stored without any further heating in glass jars covered either with parchment or with cellophane. In all cases the jars were stored in a dark cupboard for 3½ months before testing.

TABLE V.
COMPARISON OF METHODS OF COVERING.

Vegetable.	Method of Blanching.	Ascorbic Acid % Retained.	
		Stored in Jars with metal "vacuum" covers.	Stored in Jars with Cellophane covers.
Peas	Boiling Water	42.9	35.4
"	" "	52.4	37.7
"	" "	52.0	32.9
Beans	" "	23.0	8.3
"	" " + SO ₂	35.5	10.8
"	" " + SO ₂	36.8	15.5
"	Steaming 1 min.	10.9	8.5
"	" 3 min.	16.8	7.3

Fewer vegetables were covered with parchment, but where this was used the vegetables generally showed greater loss of Vitamin C than with the metal covers, but less than with cellophane.

Comparison of Dried and Salted Beans. A comparison of the cooking quality and Vitamin C content of the cooked product was made between stored dried beans and sliced beans from the same batch which had been stored in salt, using 1 lb. salt to 3 lb. beans.

The dried beans were soaked overnight and cooked for $1\frac{1}{2}$ hours. The salted beans were rinsed to remove the salt, soaked for 2 hours in warm water and then boiled for $\frac{1}{2}$ hour in this water.

The ascorbic acid contents of the cooked beans were :—

Cooked dried beans	..	..	0.25 mg./100g.
„ salted beans	..	..	0.38 mg./100g.

The quantities are so small that the beans in both cases would add negligible amounts of Vitamin C to the diet.

The cooking qualities were as follows :—

Treatment.		Colour.	Texture.	Flavour.
Blanched in boiling water, dried	..	Grey-green.	Slightly tough.	Weak.
„ „ „ with 1000 p.p.m. SO_2 , dried	..	Grey-green.	Soft.	Quite good.
„ in steam 1 min., dried	..	Green-brown.	Very tough.	Unpleasant.
„ „ 3 „ „	..	Green.	Slightly tough.	Quite good.
Stored in salt		Green, good.	Soft.	Good.

The beans stored in salt were decidedly superior in cooking quality to any of the dried beans.

B. Parsley.

Materials and Methods.

Several methods have been recommended for drying parsley. Samples from three of these, which in preliminary tests gave the best results, have been further tested for comparison of the Vitamin C content retained and the quality of the product after storage.

The freshly gathered parsley was rinsed in cold water, well shaken and either the stems removed before drying as in (a) or dried in loosely tied bunches and the stems removed after drying as in (b) and (c).

- Parsley blanched 1 minute in boiling water, cooled $\frac{1}{4}$ minute in cold water, well shaken and dried for 5 hours at 110° to 150°F .
- Bunches of parsley put in an oven at 400°F . for 1 minute, drying finished at 150°F . for 2 hours.
- Bunches of parsley dried in an oven at 240°F . for 1 hour and left without further heating in the cooling oven for another hour. Most of the parsley was then dry, but some from the centre of the bunches dried until crisp at 150°F .

The storage conditions were the same for each sample. In each case the total solids and ascorbic acid content was determined on the freshly dried material and two tests were made on the stored products; one after two months' storage in the dark in glass jars with loose glass lids and another after a further two months' storage in the dark in jars covered with parchment.

Results.

The ascorbic acid content of the fresh parsley was 265 mg./100g. The values after drying and storage are given in Table VI.

The total solids were as follows :—

Fresh parsley	17.7%
Freshly dried parsley	94.0 to 94.9%
After 2 months' storage .. .	88.1 to 89.7%

TABLE VI.
ASCORBIC ACID IN DRIED PARSLEY.

Treatment.	mg./100g. Dried Parsley.			% Retained.		
	Freshly dried.	Stored 2 months.	Stored 4 months.	Freshly dried.	Stored 2 months.	Stored 4 months.
a. ..	315	126	45	22	9.4	3.4
b. ..	508	282	119	36.7	21.4	8.9
c. ..	687	300	110	50.1	22.4	8.3

The colour and flavour were as follows :—

Treatment.	Colour.	Flavour.
a. ..	Dark Green.	Poor.
b. ..	Light Green.	Fairly good.
c. ..	Light Green.	Fairly good.

There was no very noticeable change of colour during storage, but there was a distinct loss of flavour which became more evident after the 4 months' storage, but in each test (a) was considered to have less flavour than (b) and (c).

Discussion of Results.

Blanching.

The benefit in using the same blanching water for successive batches of the same kind of vegetable was clearly shown in peas and beans in which the ascorbic acid content of the dried vegetable increased from the first to the sixth batch blanched in the same water.

The addition of sulphur dioxide to the blanching water also had a beneficial effect on the dried beans. It was not tested on the peas or parsley.

Steam blanching sliced beans for 3 minutes yielded a good product from the cooking point of view, though the Vitamin C content was low. Steaming for 1 minute was insufficient to complete the blanching.

The loss of Vitamin C during blanching was much greater in beans than in peas.

Parsley blanched in boiling water before drying gave a dark green product, but the flavour was poorer and the ascorbic acid content lower than in other samples dried without blanching.

Drying.

Peas dried in the air lost considerably more Vitamin C than those dried by heat treatment. There was a greater loss in the dehydration of beans and parsley than in peas.

Two methods of drying parsley have given good results; these are heating the parsley in an oven at about 400°F. for 1 minute followed by drying till crisp in a slow oven, and drying in an oven at about 240°F. for 1 hour, and leaving it in the oven until cool. The latter method would generally prove easier in the home.

The advantage of having a drier constructed which has a good current of air to remove the steam was noticeable in that the time of drying was reduced by more than half of that needed in a steam oven with the doors left slightly ajar.

Covering and Storage.

A significant difference was noticeable in the Vitamin C content of peas and beans stored in jars with reduced air pressure compared with others stored in jars covered with cellophane, the latter giving decidedly lower results. The effect of covering with parchment was not fully tested, but this method appears to be less detrimental to the Vitamin C content than the use of cellophane. There was a serious loss of Vitamin C in beans, peas and parsley on storage in all the methods tested.

Vitamin C Content and Cooking Quality.

There appeared to be no definite correlation between the Vitamin C content and the cooking quality of the vegetables. Peas dried in the air were considerably lower in Vitamin C content than any of those dried under heat and yet were intermediate in their cooking quality. There was also no significant difference in the appearance and flavour of peas or beans which were dried by the same method and stored with different types of cover though the Vitamin C content varied considerably. By the time the stored beans had been soaked and re-cooked there was a negligible amount of Vitamin C retained whichever method of drying was used or whether salting treatment had been given, but salted beans were superior in cooking quality.

Summary.

Experiments of a preliminary nature were made to see whether various methods of drying vegetables under domestic conditions yielded appreciable differences in the Vitamin C content and cooking qualities of the stored product.

The chief points noticed were :—

1. Peas dried and stored under domestic conditions yielded products higher in Vitamin C when heat was used for drying than when the peas were dried in the air.

2. Dried beans were less satisfactory than beans stored in salt. In both cases the Vitamin C in the beans cooked after storage was very small.

3. The method of blanching used before drying the vegetables made a considerable difference to the dried product.

4. The method of covering for storage is an important factor in retaining the Vitamin C content.

5. Two methods of drying parsley gave good results, though there was a high loss of Vitamin C during storage in jars which were not air-tight.

TESTING RAW MILK SUPPLIES FOR KEEPING QUALITY UNDER THE NATIONAL SCHEME.

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In pursuance of the Government policy for the Milk Industry announced in the White Paper (Command 6362) published on the 3rd June, 1942, the Minister of Agriculture and Fisheries in consultation with the Minister of Food and the Minister of Health appointed an Advisory Committee to supervise a national scheme for improving the keeping quality of all milk supplies. The primary objects of this scheme, now known as the National Milk Testing and Advisory Scheme, are as follows :—

- (a) To encourage and assist milk producers and distributors to maintain a satisfactory standard of keeping quality for all milk supplies.
- (b) To reduce loss of milk from souring or tainting and, in particular, to safeguard the keeping quality of bulked market milk, by segregating producers' milk which is not satisfactory for the liquid market on its arrival at the dairy, depot or creamery.
- (c) To provide a suitable basis for the introduction, as soon as practicable, of a scheme of differential prices to producers in accordance with the keeping quality of the milk delivered.

The scheme came into active operation in the Bristol Province in July when official testing of producers' milk supplies was introduced in some areas. Since then considerable progress has been made, and the testing has been extended so that, at the present time, practically all raw milk supplied to the larger creameries and depots is subjected to the keeping quality control tests.

Sampling and Testing.

The Advisory Dairy Bacteriologist is responsible to the Ministry of Agriculture for the organisation, supervision and control of sampling and testing for purposes of the scheme. For convenience, raw milk supplies are sampled, whenever practicable at the point of first delivery, by authorised and competent persons. The methods of sampling have been standardised throughout the country and the treatment of samples prior to testing is also uniform.

Creameries and depots with not less than 100 suppliers or handling not less than 2,000 gallons of raw milk daily, have been asked to provide laboratory facilities and testing personnel to apply the approved tests to their own supplies. At smaller depots and dairies, samples of suppliers' milk will be taken, and tested at an approved laboratory under the control of the Advisory Dairy Bacteriologist. Since the success of a scheme of this nature depends to a considerable extent upon its being strictly impartial, and in view of the fact that the testing may lead to price differentiation, the laboratories and testing personnel have to be approved and licensed by the Advisory Dairy Bacteriologist, who subsequently maintains adequate control and supervision

and may arrange for frequent check tests to be made by his own staff. Two tests have now been approved for use under the Scheme, both being designed for measuring the keeping quality of raw milk, namely, the Standard Platform Test and the Standard Routine Test.

Standard Platform Test.

This is a rapid test designed for detecting milk of such poor keeping quality that it will lead to the premature souring or tainting of bulk milk to which it is added. The test is applied to any producer's milk supply that is suspected to be of poor keeping quality when it arrives at the dairy, depot or creamery. By the application of this test it is possible to sort milk supplies into three categories as follows :—

- (1) Market Milk—milk which is acceptable for the distant liquid milk market.
- (2) Salvage Milk—milk of relatively poor keeping quality which would not remain wholesome if consigned long distances, and which would endanger the quality of bulked market milk. Arrangements are being considered for salvaging milk in this category.
- (3) Rejected Milk—milk of very poor quality which is returned to the producer.

Thus, salvage milk and rejected milk are regarded as being of unsatisfactory keeping quality. The standards for these two categories are very low ; broadly speaking they correspond to bacterial counts in the region of 5,000,000, and 100,000,000 per one millilitre (20 drops) of milk, respectively. Comparing the standards with those of the methylene blue test, salvage milk standard is equivalent approximately to a methylene blue reduction time of between 10 minutes and 30 minutes, whereas rejected milk will normally show a methylene blue reduction time of less than 10 minutes. Therefore, it will be noted that the standard for unsatisfactory milk is far below the standard for accredited milk when the methylene blue reduction time has to be not less than 5½ hours in winter and 4½ hours in summer. Indeed, when milk is placed in the rejected category under the Standard Platform Test, it is very evident that the methods of production and management on the farm are grossly unsatisfactory.

A survey of the test results obtained at licensed laboratories in the Bristol Province, since the inception of the Scheme to 30th September, shows that out of a total of 24,000 tests carried out on milk supplies suspected to be of poor keeping quality, approximately 20% were unsatisfactory ; these supplies were fairly equally divided in the salvage and rejected categories.

Standard Routine Test.

While the Platform Rejection Test is invaluable for segregating milk of poor keeping quality before it is handled at creameries and depots, it can only be operated at the larger dairies where laboratory facilities exist. Moreover, its application is largely seasonal, that is, in summer time when the atmospheric temperature is relatively high.

It has been decided, therefore, that any permanent scheme for improving the general standard of the milk supply and for operating an advisory service to milk producers, should be based on regular routine testing of all producers' milk supplies throughout the year. To serve this purpose, the Standard

Routine Test has been adopted. Like the Standard Platform Test, it is a Resazurin Test, the principle of which is the dye reduction of the milk, the rate of reduction depending on the keeping quality. In order to simplify the interpretation of the results, for the benefit of producers the quality of the milk is expressed as a number as follows :—

Standard Routine Test No.	Category.	Interpretation.
6 to 4	A	Good keeping quality.
3½ to 1	B	Moderate „ „
½ and 0	C	Poor „ „

The Standard Routine Test is a more searching test than the Standard Platform Test since the milk is not tested as soon as it arrives at the creamery or dairy, but is held at atmospheric shade temperature for a specified time.

Milk placed in Category A is of satisfactory quality for all commercial purposes, whereas, Category C, and Category B milk with a Test No. of 2 or less, must be regarded as unsatisfactory.

The Standard Routine Test has been applied to the milk supplies received at large creameries since 1st October, and the test is now being extended to supplies delivered to smaller dairies.

Analysis of results obtained so far for samples tested in the Bristol Province shows that approximately 5% of producers' milk falls into Category C, and about 10% into Category B.

The work of equipping laboratories and of training testing personnel—already over 100 testers have been certificated in the Bristol Province—is proceeding as rapidly as possible, and it is hoped that all producers' milk supplies will be subject to one or both of the approved tests before next summer.

Advisory Work.

Producers of milk in the Salvage or Rejected Categories under the Standard Platform Test, and of milk with a Test No. of 2 or less under the Standard Routine Test are notified by a letter from the Advisory Dairy Bacteriologist. At the same time, the names of these producers are forwarded to the County War Agricultural Executive Committees so that their technical officers can visit the farms and give advice.

While an endeavour is being made to improve the methods of milk production on farms where necessary, by education and advice, corresponding advice is available to creameries, depots and dairies so that improvements in the handling and processing of milk can be achieved. The advisory work at milk buyers' premises is the responsibility of the Advisory Dairy Bacteriologist. In this connection the chief problem that demands advice is the methods of churn cleansing. A vast improvement in the condition of churns returned to producers has already been achieved since the introduction of the scheme, although in some dairies churn cleansing facilities are still inadequate.

The launching of this scheme has been no easy task. Innumerable difficulties have had to be overcome, but the willingness of creamery and depot proprietors to provide testing facilities resulted in a successful start being made soon after the scheme was announced. Milk producers can be assured that the tests are scientifically sound in principle and accurately applied in practice. It is hoped that they will show a deep interest in the scheme and if necessary take steps to ensure that their supplies are of "Market" and "Category A" quality and thus avoid wastage of our most valuable foodstuff.

THE CONTROL OF ANIMAL DISEASE. STERILITY IN DAIRY HERDS.

By D. W. MENZIES, M.R.C.V.S.

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During the past year work in the laboratory has been devoted to routine diagnosis and investigations into local outbreaks of disease. Contrary to expectations poultry work showed an increase over the previous year, but the greatest increase in specimens occurred in connection with diseases of dairy cattle.

The introduction by the Ministry of Agriculture and Fisheries of the Scheme for Control of Certain Diseases of Dairy Cattle on June 1st, 1942, has greatly influenced the type of work carried out by the laboratory. Under this scheme a farmer may make a contract with his veterinary surgeon to advise him on the control of mastitis, contagious abortion, Johne Disease and sterility and to carry out the necessary preventive measures, *e.g.* inoculation against abortion, and curative treatments, *e.g.* udder infusion for mastitis. The annual charge works out at 10/- to 12/6 per adult animal in the herd, depending on the number of animals involved, and at 2/6 for each heifer six months old to day of calving. Abortion vaccines are supplied free of charge and sulphanilamide, which is extensively used for mastitis, is supplied, at a greatly reduced cost. Blood tests and bacteriological examination of milks are also carried out free of charge. The scheme represents an advance in that adequate veterinary supervision is available for certain herds and the health of the herd as a whole will receive much greater attention than hitherto. Preventive measures necessary in disease control will also be considered in detail. One can visualise that the vaccines for the control of contagious abortion will be very extensively used in the future, for only in certain circumstances is eradication of the disease recommended. Self-contained herds represent the most satisfactory subjects for an eradication policy but, even in these cases, the new abortion vaccines may be administered as an "insurance" now that an adequate supply of milk is such an urgent necessity.

Sterility is one of the most serious of the problems to be tackled, as it demands so much of all concerned. There is no simple, easy remedy for sterility. A cynic has remarked of this condition that "patience is as likely to be rewarded as perseverance." In any case, it is essential that the farmer keeps accurate records of all his cows, calving dates, service dates, etc. The veterinary surgeon on his part has to examine every cow—a gruelling and not one of the most pleasant tasks—and carry out any treatment which may be necessary. It is possible in many cases to tell when an animal is in calf six weeks after service, but there are also doubtful cases which require further examination three to six weeks later. It is interesting to note that a considerable number of cows which the farmer is certain are barren are found on examination to be actually in calf. This has been confirmed in the past at slaughterhouses where many of the "barreners" have been found pregnant. With frequent

veterinary examinations, losses of this nature should be eliminated and this is only one of the many advantages which accrue from continuous supervision of dairy herds where sterility is rampant.

As for the conditions encountered in cases of sterility, there are an infinite variety. The generative organs may appear perfectly normal or may have lesions which render the animal quite unfit for breeding, in which case the cow should be removed from the herd. Certain ovarian disorders may be diagnosed which require attention by the surgeon. The administration of hormones, synthetic or natural, recently marketed may be all that is required to obtain the desired result. Chronic inflammation of the uterus may be present—in such slight degree that detection is difficult—or the cow may show obvious clinical signs of this condition. Such a case may require repeated uterine irrigations before a cure is effected.

The laboratory plays an important part in planning measures for the treatment of sterility, and in the past year there has been a notable increase in demands for assistance from practitioners engaged on this type of work. Blood agglutination tests for *Brucella abortus* are usually carried out together with bacteriological examinations of aborted fetuses, uterine discharges, etc. As a result of bacteriological examinations the organisms isolated can be classified into groups of low pathogenicity amenable to treatment and those of greater virulence which will require a long course of treatment. The unexpected is sometimes encountered in herds with an atypical history or it may be necessary to transport laboratory equipment to the farm to carry out examinations on the spot, as in the case of sterility following *Trichomonas* infection.

Close co-operation between the veterinary practitioner and the laboratory has always been sought and has largely been accomplished, and the new scheme will tend to weld together the farmer, practitioner and laboratory, for it is only by the utmost efforts of all three that success in obtaining a measure of control over the conditions that bring such serious individual and national losses in the milk industry can be attained.

THE ECONOMIC ASPECT OF FARMING OVER FOUR YEARS.

By C. V. DAWE, M.Com., Ph.D.
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This article, which summarises the economic and financial results on 118 farms for the year 1941/42, should be read in conjunction with the similar article in the Annual Report of the previous year.

The farms now examined include large and small farms of various types drawn from the five counties which comprise the Bristol Advisory Province. In many ways it would have been more satisfactory to have divided these farming results into groups according to the type of farming carried on by the particular group, but the total number is insufficient for a satisfactory system of grouping to be adopted.

The aggregate acreage of these farms amounted to 33,767 acres, of which 11,389 acres, or roughly one-third, was arable. Included in the total acreage are 2,978 acres of rough grazings and 593 acres which, although included in the total acreage, cannot be regarded as farmland; this acreage is absorbed by woodlands, buildings and roads. The total rental of these farms amounted to £42,060, equivalent to 25/- per acre. This rental includes the rental value of farmhouses and cottages.

Profits have not merely been well maintained, but have increased from a total of £107,497 to £147,234. This is a net profit arrived at after charging in the accounts £16,271 for the value of manual work performed by the farmer himself and members of his family, and after charging the recognised rates of depreciation on farm machinery. On the other side, credits are given for the rental value of the farmer's house and farm produce consumed in the house.

All accounts are regarded as being those of tenant farmers, so that in cases where the farmer is owner-occupier the gross rental value as assessed for Schedule "A" is included; landlord's repairs such as repairs to buildings are excluded. In the accounts for the year 1941/2 there has been included for the first time the War Damage Contribution. Such contributions are not allowed by the Inland Revenue authorities to be charged as an expense against farming, but in these accounts they have been so charged.

This net profit is 36% above that of the previous year and perhaps it will be clear if it is stated that, whereas in 1940/41 the average net profit amounted to £911 per farm, or to 65/- per acre, in 1941/42 it amounted to £1,248 per farm, which is equivalent to 82/- per acre. Of the 118 farms it may be noted that four farms made losses in 1940/41 as compared with none in 1941/42.

It should, perhaps, be made clear that in calculating profits the usual method has been adopted, namely of including with the difference between cash expenditure and income the difference between the opening and closing valuations. Thus, the aggregate profit in 1941/42 of £147,234 consists of a cash margin of £98,072 plus the amount of £49,162 which represents the difference in valuations.

Labour.

The labour bill has probably the largest single influence on profits and, as is well-known, there have been several increases in the wage rates since the outbreak of war, and various estimates have been made as to the effect of such wage increases. It should be pointed out that in all considerations of costs it is not so much the absolute as the relative figure that matters, namely the proportion that a particular item absorbs both of the total farm costs, and, more especially, of the total farm income. In short, it is no argument to say that high wage rates necessarily mean a high labour cost, for apart altogether from the considerable rises in prices of agricultural commodities which have occurred, the history of farming shows that as wage rates increase the efficiency of the worker also increases. Generally speaking, this kind of thing occurs in all industries as well as in farming.

Applying this argument to the present figures, it is found that in spite of, or possibly because of, the increases in wages rates, the proportion of the total farm cash income absorbed by the wages bill has remained approximately constant over the four years since 1938/39, at $23\frac{1}{2}\%$. Admittedly, wage rates have increased more than certain items of farm expenditure, but even so they now account for only 29% of the total farm expenditure as compared with 24% in the last year of peace.

A good deal has been said during the war about the shortage of farm labour. There are four aspects. One is the actual shortage in numbers as compared with pre-war years; the second is the relative shortage having regard to the increased output of produce from farms; the third is the frequency with which workers have left and have been replaced; and the fourth is the quality of the labour which has been engaged to replace that which has left.

Of the last two there is no adequate record, but in regard to the first it is interesting to note that, whereas in 1939 there were 4.25 men per farm, there are now 4.95 men per farm. With regard to the second point, namely the relative shortage of labour, it is again difficult to give an exact statement since, as has just been shown, the number of male adult workers per farm is higher now than in pre-war days. A simple comparison cannot be made because of the greater proportion of female and casual labour in use. One is, therefore, thrown back upon the method of measuring the efficiency of the total labour on the farm by comparing the total farm output with the total wages bill and, since on the farms under review an appreciable amount of manual work is performed by the farmer himself, there should be included for this purpose the monetary value of the farmer's own work. By this method the total farm production in 1941/42 amounted to £402 per £100 of labour cost, as compared with £451 in the previous year, and £316 in 1938/39. To what extent this improvement in output is due to a more intense effort in regard to labour management in farm production generally on the part of the farmer, or to harder work on the part of the worker, is extremely difficult to say. The question is further complicated by the fact that the monetary value of the farm output has to be used, which involves the problems of price increases for various farm commodities, instead of making use of the actual physical output, but this in turn is impossible owing to there being no common denominator between crops and livestock, except the rather unsatisfactory one of money values.

Apart altogether from the discussion of the labour cost in total and its relationship to farm output, it will perhaps be useful to make a comparison of the cash wages earned by the individual worker. There has been a substantial improvement in such wages over the period of four years, mainly due to increases in rates of wages made by the Central Wages Board in conjunction with the County Wages Committees, but partly also to the increased amount of overtime which has become more and more necessary as the intensity of farming has increased.

It must be pointed out that in all cases the cash wages form only a part of the total wages received by the workers. In the case of men and boys the cash wages represent nearly the entire wages and only a small amount should be added. Probably a figure of 1/6 per week is sufficient in the case of men and a few pence in the case of boys. In the case of women workers, however, the cash wages form a much smaller proportion of the total wages, especially during the last two years, chiefly on account of the fact that a larger proportion of women workers are boarded in the farmhouse, especially if they are members of the Women's Land Army. The average amount per woman worker for such wages in kind can be put at approximately 4/- per week. The wages in kind for men usually consist of a cottage, with or without free milk.

One other way of looking at the labour cost is to say that the present labour cost per acre, namely cash wages plus wages in kind, amounted in 1941/42 to 81/6 per acre of crops and grass as compared with 72/2 in the previous year and to 57/6 in 1938/39. In arriving at this figure the cost of the manual work performed by the farmer himself has been included on the assumption that if he did not himself perform such manual work, additional labour would have to be employed. The value of casual labour has also been included in this acreage figure. The difference over four years between 57/6 per acre and 81/6 per acre represents a rise of 42%, but if it be assumed that the average standard rate of wages for adult male workers in 1938/39 was approximately 32/- per week and is now, at the time of writing, 60/- per week, the percentage increase in standard rates amounts to nearly 100%.

There has, of course, been a certain amount of substitution of skilled labour, but, as has just been shown, such substitution has not been of appreciable importance. This substitution, however, must not be ignored when stating that the labour cost per acre has risen by only 42%, but, obviously, had not such substitution occurred, the labour cost per acre would have been only a little higher than the present figure of 81/6 per acre. In brief, therefore, the fact that standard rates have increased by 100%, and actual labour costs by approximately 42%, gives an indication of the greater efficiency of both workers and farmers and, in some measure, of the greater keenness in producing the larger food supply required by the community.

It is difficult from the information available to assess the degree of dilution of skilled labour which has occurred through the necessary employment of various grades of casual workers such, for instance, as schoolboys and prisoners of war, but some impression may be obtained when it is mentioned that in the year before the war the total bill per farm for all types of casual labour amounted to only £23 as compared with a bill of £27 in 1940/41 and £48 in the past year 1941/42. Even this last figure, however, is of very minor

importance in the total labour cost, amounting as it does to only one-twentieth of the total labour cost.

Before concluding this section on labour it should be noted that, in addition to the ordinary farm labour, the amount of contract work carried out on the farms under review by outside people, either by other farmers, independent contractors, or County War Executive Committees, amounted to a figure of £3,827 compared with £2,343 in the previous year, but it must be made clear that on the other hand these 118 farmers themselves carried out contract work on other farms amounting to £2,555 in 1941/2 compared with £2,275 in 1940/41, so that the aggregate net cost on these 118 farms only amounted to £1,272 in 1941/42 and £68 in the previous year.

The Production of Livestock and Livestock Products.

Cattle. A total of 8,939 head of cattle were carried on the 118 farms in 1941/42, valued at £184,812. Of these, cows numbered 4,226, worth £104,887, and in addition there were 625 heifers in calf, valued at £14,770.

During the year these farms produced livestock and livestock products to the value of £329,456, equivalent to £2,792 per farm, this figure being net; that is, the gross output less purchases of livestock. In the previous year this net production amounted to £2,897 per farm and in the year before the war to £1,987. These figures may be interpreted to show that in 1941/42 the output of livestock and livestock products amounted to £9 15s. 0d. per acre compared with £10 10s. 0d. in the previous year and £6 2s. 0d. in the year 1938/39. It will be obvious that this increase in the money value of the output cannot be regarded simply as measuring the increase in the physical output of produce, since prices have risen considerably during the war. Thus, the average farm selling price of fat bullocks and heifers (including subsidy) rose from £22 per head in 1938/39 to £30 per head in 1941/42. Fat lambs have risen from an average of 37/6 to 58/6 per head, baconers from 107/- to 151/- per head, wholesale milk from 12d. to 20d. per gallon, wool from 10d. per lb. to 16d., and eggs from 1/5 to 2/9 per dozen.

It is well-known that certain changes have occurred in the numbers and types of livestock carried since the outbreak of war. In the case of the dairy herd, however, there were in 1938/39 approximately 36 cows in milk per farm, and in 1941/42 this figure again held good. An examination of the figures for heifers in calf corroborates the above statement that the dairy herd has remained stationary over the four years. If, in addition to the dairy herd, other classes of cattle are included, then in pre-war days there were 75 head per farm, as compared to-day with 76 head per farm. A study of the intervening years shows, however, that in the year 1940/41 the average number of cattle carried per farm had increased since the outbreak of war to 79 head.

The value of milk production has consistently formed the largest single item of output from farms in the Bristol Province, although, owing to the exigencies of war, more and more emphasis has had to be placed on sale crops. In 1938/39, 583 gallons per cow-in-herd were produced, but the yield fell to 575 gallons per cow in 1939/40 and to 530 in 1941/42. The net result is that in the pre-war year the average daily yield per cow-in-herd amounted to $1\frac{2}{3}$ gallons, as compared with $1\frac{1}{8}$ gallons in 1941/42. This represents a fall during the war of $\frac{1}{8}$ in the milk production of the Bristol Province on this sample

of farms. The sale value of milk per farm amounted in 1938/39 to £1,070 and in 1941/42 to £1,642.

Apart from the sales of milk there are, of course, sales of cows and cattle, some of which relate to culled cows, others to milking cows and heifers, and others to fat bullocks and heifers fit for beef. The total number of all types of cattle sold from the 118 farms in 1941/42 was 6,154 head for £85,859; this is an average of 52 head for £728 per farm. In 1938/39 the per farm figures were 52 head for £480. Thus, while the numbers have remained the same, the value has increased from £9 5s. 0d. to £14 per head. These low average prices per head are, of course, due to the fact that since the dairy herd is included with the other cattle the sales of young calves amount to a high proportion of the total number of head sold. However, the prices of fat bullocks and heifers have been referred to above. The number sold of these beef cattle has remained approximately stationary over the 4 years at $8\frac{3}{4}$ head per farm, and although this figure cannot be regarded as high, the total sale value of the animals represented as much as 39% of the aggregate sales of all classes of cattle in 1938/39 and 36% in 1941/42. The surprising fact is that during the four years since 1938/39, with all the difficulties of feeding the dairy herd and the pressure of work on the land, the numbers of cattle carried have remained approximately the same.

Sheep. Of the 118 farms under review 71 farms were keeping sheep at the end of 1941/42. The total number of sheep carried amounted to 9,963, valued at £28,371, and if these figures are spread over the 118 farms they average 85 sheep per farm, whereas the corresponding figure for 1938/39 was 124 head. During the war the ewe flock has been reduced by nearly one-half, namely from 96 to 50 ewes per farm. Ewes were valued on the average at 49/6 per head in 1938/39, and at 64/3 per head in 1941/42, but their lowest value was 43/9 in 1939/40. Sales of sheep in 1941/42 from the 118 farms totalled 12,996 head at £39,893, which is equivalent to 110 head per farm for £338. In 1938/39 the average number sold per farm amounted to 121 head for £231. Approximately three-quarters of the total head of sheep sold consisted of fat stock, and this proportion has remained constant during the four years.

The output of wool from the 118 farms in 1941/42 totalled 50,567 lb., which is equivalent to 430 lb. per farm and may be compared with the average of 460 lb. per farm in 1938/39, but in 1940/41 it was as high as 505 lb. per farm. Thus, during the last two years the output of wool per farm has fallen by one-seventh.

Pigs. During 1941/42, 89 farms out of the 118 kept pigs. The total number of all classes of pigs amounted to 2,415 in 1941/42, valued at £9,779, which is equivalent to 18 pigs per farm. In 1938/39 the total number of pigs carried per farm amounted to 64. It is interesting to find that the pig population increased somewhat during the first two years of the war, but fell heavily by the end of 1940/41, and, as has just been shown, has fallen still more heavily. If the numbers of sows be considered, however, the breeding herd has declined consistently since the year before the war from an average of 7 to $2\frac{1}{2}$ sows per farm in 1941/42. The greatest falls, as perhaps might be expected, occurred in the last two years, when in each of these years, the farms finished up with half the number of sows they commenced with.

Turning to the sales of pigs of various types during the four years, the total numbers sold during the first three years remained fairly constant at approximately 140 pigs per farm, but in 1941/42 the numbers were roughly halved at 74 pigs per farm. Obviously, there has occurred during the past year a considerable selling off of the herds themselves. This is corroborated by the fact that in the first two years, purchases of pigs remained steady, but fell rapidly in the third and fourth years. In fact, in the fourth year, the number of pigs purchased was only half that of the previous year. Throughout the four years the bulk of the sales has consisted of bacon pigs, which in the first three years accounted for approximately two-thirds of the total number of pigs sold, but in the fourth year, because of the inability to feed pigs to bacon standards, farmers were forced to sell a larger proportion of other pigs, so that in that year the proportion of baconers amounted to only half the total. Although porkers form a relatively small portion of the total sales of pigs they, too, have fallen in numbers somewhat similarly to baconers. Store-pig selling prices, which here must be taken as covering all types of stores, increased from 38/6 per head in 1938/39 to 54/8 in 1940/41, and to 55/- in 1941/42. On the purchase side stores began at 42/- per head and rose to 53/- by 1941/42.

Poultry. In 1941/42 the total number of poultry carried amounted to 13,444 birds, valued at £4,871. If this total is spread over all the farms, the average flock carried amounts to 114 birds per farm in 1941/42, which may be compared with a flock of just under 200 birds in 1938/39. It is interesting to note that during the first stages of the war there was a marked tendency for the total poultry flock to increase, but in the year 1940/41 there occurred a sharp fall in the number of poultry, which amounted to approximately one-third of the total flock. By the end of 1941/42 there had occurred a further decline of one third. Insufficient information is available to calculate the average number of eggs laid per bird, but the total number of eggs sold per farm amounted in 1938/39 to 1,240 dozens and in 1941/42 to 970 dozens. The sales of birds per farm amounted to 76 in 1938/39, at an average price of 3/9 per head, and to 72 in 1941/42 at an average price of 7/4 per head.

Horses. There has been a very slight tendency for the number of working horses per farm to fall during the period under review. While in 1938/39 the average number of horses amounted to $4\frac{3}{4}$ per farm, equivalent to one horse for every 50 acres, in 1941/42 the average number of horses amounted to $4\frac{1}{4}$ per farm, which is equivalent to approximately one horse to every 60 acres. Thus, in spite of the very considerable increase in the number of tractors, the numbers of horses have remained very nearly the same. Possibly both horses and tractors are required in order to cope with the greater proportion of arable land, as a result of the necessities of war, but one is left with the impression that in many cases horses are not being used to anything like full capacity.

Feeding Stuffs.

There are various types of feeding stuffs, so that it is not possible to give a simple statement of the quantities purchased. The feeding stuffs bill per farm increased from £830 in the first year to £1,000 in the third year, but by the fourth year the bill had fallen to £610. The increase in the feeding stuffs

bill in the early part of the war was naturally due to the rising trend of prices, and the sudden fall in 1941/42 was obviously the result of the acute shortage of feeding stuffs available for purchase. On account of the quantities and types of home-grown feeding stuffs used, it is difficult to relate the food bill to the output of livestock and livestock products, but that there has been a very large margin which has been made good by the feeding of home-grown foods is clear from the fact that, while the index of livestock production has increased over the four years in monetary value from £100 to £141, the bill for purchased feeding stuffs has decreased from £100 to £74.

Crops.

Of the total area of 33,174 acres under crops and grass, 9,710 acres were under tillage, 1,679 acres were under temporary grass and 18,808 acres were under permanent pasture, leaving 2,977 acres under rough grazings. In view of the ploughing-up campaign it is interesting to note that, whereas in 1941/42 one-third of the total farm acreage was under arable (including temporary grass), in the year before the war the fraction was one quarter. The net result is that on these 118 farms, after three years of the ploughing-up campaign combined with the advice of scientists to put more land under rotational grass, there is now as much as two-thirds, as compared with three-quarters in peacetime, of the total acreage of these farms still under permanent grass. Rotation grass even now accounts for only one-twentieth of the total farm acreage.

In spite, too, of the great efforts made to encourage the production of silage of various types, there are few farms among these 118 that have embarked upon silage making. Only 22 farms in 1941/42 produced grass silage from permanent pastures and the total area so used amounted to only 475 acres. Similarly, only 7 out of the 118 farms produced silage from temporary grass, and here the total acreage so cut amounted to only 96 acres. Moreover, only 6 farms produced arable silage, on a total of 38 acres, but of these one farmer alone accounted for 25 acres, thus leaving 5 farms to share 13 acres of arable silage among them. The result is that, of a total farm acreage under all crops and grass of over 33,000 acres, only 609 acres were utilised for silage of all types; this is less than one acre in 50. The total estimated weight of silage made amounted to 1,618 tons, which is equivalent to an average of $13\frac{3}{4}$ tons per farm of approximately 280 acres.

Other fodder crops, too, have not expanded their acreages as much as one might have expected. This in itself is not disappointing, for it may indicate more careful feeding of such crops to livestock, but on the other hand the relatively small increase may be one of the main factors in the lower yields of milk per cow which have caused a certain amount of anxiety during the last year or two. By fodder crops is meant crops such as mangolds, turnips, swedes, kale and cabbage, and the combined acreage of such crops is now only 13 acres per farm compared with 9 acres before the war.

Hay is still the farmer's great standby, and in 1941/42 something over one-third of the permanent grass and two-thirds of the temporary grass was cut for hay, the total acreage on the 118 farms being 6,893 and 1,205 respectively. With an average yield of $23\frac{1}{2}$ cwt. of meadow hay per acre the total tonnage lifted amounted to 8,087 tons and in the case of hay from rotation

grass the total tonnage lifted amounted to 1,670 tons, giving a yield of nearly 28 cwt. per acre. In other words, the figures are 10 tons of rotation hay and 68 tons of meadow hay per farm.

In addition to fodder crops and hay, more straw is being fed to-day than previously, partly because of necessity and partly because, owing to the increased area under corn crops, more straw is available. If wheat straw be omitted, since it is not suitable for feeding unless it has been processed, then the total quantities of other straws available for feeding amounted on these 118 farms to 1,687 tons in 1938/39 and to 3,941 tons in 1941/42, assuming an average yield of 1 ton of straw per acre. This means that there is now $2\frac{1}{2}$ times as much straw available for feeding as compared with pre-war days. On a farm basis, there were in 1938/39, 14 tons of straw suitable for feeding, as compared with 33 tons to-day. If, however, wheat straw were passed through the caustic soda treatment, an additional quantity of straw of 3.028 tons (in the dry state), equivalent to 25 tons per farm, would be available. This, however, is not possible, since there are not more than 6 of these 118 farms which have a straw pulping plant. No doubt there are limiting factors other than cost and labour shortage that prevent more farmers being equipped with straw pulping plants, and of these probably the chief is inadequacy of suitable water supplies. In fact, it is probably true to say that the greatest single factor retarding the rapid extension of farm production in all its aspects is adequate water of a high standard of purity.

In concluding this section on home-grown foodstuffs, it can be assumed that the whole of the mixed corn crop was fed, as well as the whole of the bean crop. On these farms in 1941/42, 860 acres were under mixed corn and 200 acres under beans. The average yield of the former was 15 cwt. per acre, giving a total yield of 646 tons and that of the latter $19\frac{1}{2}$ cwt. giving a total of 196 tons. In addition, some threshed peas were available for feeding, but these amounted to only 16 tons. The rapid increase in the acreage under mixed corn since the outbreak of war is noteworthy. In 1938/39 none of these farms grew mixed corn, in the following year there were 2 farms growing this crop, 26 in 1940/41 and 35 in 1941/42.

Seventy-three of the 118 farms grew oats, and it is estimated that about two-thirds of the crop was fed to stock. The total acreage under oats was 1,677 acres, which gave an average yield of 15 cwt. per acre, resulting in a total production of 1,255 tons, so that it can be stated that about 800 tons, which is equivalent to $6\frac{3}{4}$ tons of oats per farm, were available for feeding.

Fifty-three farmers grew barley, the total being 1,405 acres, which at a yield of nearly 18 cwt. per acre gave a total production of 1,255 tons. Naturally, a much smaller proportion of the barley crop was fed, probably between one-fifth and one-quarter.

There was a small bulk of sugar beet tops available for feeding on the 17 farms that grew this crop. At an estimate of 10 tons of tops per acre, the total quantity available can be put at 1,500 tons.

Crop Sales.

Aggregate crop sales amounted to £104,577 in 1941/42, which is equivalent to approximately £3 10s. 0d. per acre of crops and grass, excluding rough grazings, or £887 per farm. Of this total income, the sales of wheat totalled

£26,024, which averaged 14/10 per cwt. as compared with 8/6 before the war. There was a wheat acreage of 3,028 acres, and the importance of this crop can be judged from the fact that it accounted for approximately one-third of the total acreage under the plough, excluding temporary grasses. If this proportion is compared with that of the year before the war it is found that the figure was then actually higher at 37%, due to the much smaller proportion of the total farmland under the plough at that time. In terms of wheat acreage, however, it can be stated that, whereas before the war there were only 20 acres of wheat per farm, there are now 26 acres. This cannot be regarded as a large increase per farm and further examination shows that the number of farmers growing wheat for the first time has also not greatly increased, so far, at least, as these records show; for while two-thirds of the number of farmers grew wheat before the war the proportion is now no more than three-quarters. The yield per acre at 18½ cwt. is slightly below the 18.4 obtained in 1938/39, but is higher than the two intervening years, which produced 16.7 and 17.2 cwt. per acre respectively.

The total value of barley sales at £26,631 was slightly more than that of wheat, but the average selling price was 25/11, as compared with 9/11 per cwt. just before the war. It should be noted in passing that only two or three of the 50 farmers growing barley were successful in selling at the phenomenally high barley prices that were reached during the season. The total area of barley grown amounted to 1,405 acres, which is something less than half the acreage under wheat and may be compared with the 1,677 acres under oats. As mentioned in the section on home-grown feeding stuffs, practically two-thirds of the oat crop was fed, leaving approximately one-third, or 9,411 cwt., for sale which fetched an average of 15/3 per cwt. and this may be compared with 7/5 before the war.

Of all the sale crops, the third in importance from the point of view of total sale value is potatoes, which were grown on 82 farms. The total sale value of this crop amounted to £12,261 at an average price of £5 17s. 0d. per ton. This price per ton was almost identical with that of 1940/41, but is considerably above the figure of £3 19s. 0d. obtained just before the war. The total acreage grown amounted to 503 acres and the average yield was 7.3 tons per acre. This yield is the lowest for four years; in the year before the war the average yield on these farms amounted to 10.3 tons, and was 8.7 tons in 1939/40 and 8.6 tons in 1940/41. The reason for this decline in yield is probably mainly due to the extension of potato growing to those farms where potatoes had not previously been grown, combined with the necessity of growing them in unsuitable soils. The extent to which this has occurred may be judged from the fact that, whereas before the war only 4 out of 10 of these farmers grew potatoes, the proportion is now 7 out of 10.

In some ways the sugar beet crop on these farms is a rival to potatoes, and, in general, farmers have been encouraged to grow beet, partly on account of the need for sugar by the community and partly because of the value of beet tops, already referred to, for feeding to livestock. Examination of the present records, however, shows that in the year before the war the average acreage of beet grown per farm was 1½ acres, which has now fallen to 1½ acres. In both years approximately only 1 in 7 farmers were growing beet; but even on this seventh the average acreage only amounts to 9 acres, as compared with 13 before the war. The yield of washed beet amounted in 1941/42 to

8 $\frac{2}{3}$ tons per acre, and it is noteworthy that this yield is the lowest of the four years under review. The whole of the beet crop was sold for £3,951 and the average price received amounted to 59/- per ton, as compared with 37/3 before the war.

Flax production has been unimportant. Only 131 acres were grown, either for fibre or for linseed. This acreage must be compared with the 191 acres under various types of market garden crops, excluding potatoes. These crops were not produced on specialised market gardens, but form part of the general farm economy. The orchard acreage, which has remained steady over the four years at approximately 450 acres, did not figure largely in the pre-war sales of crops, but in 1941/42, and in spite of the fact that this was not a very good year for orchard fruit, the value of sales amounted to £3,941, which is equivalent to £9 per acre. In the previous year it was only £2 per acre.

To conclude this section on crop sales, it is only necessary to refer to the sales of hay and straw. In the case of the former a total of 172 tons of hay were sold for £1,246, thus averaging £7 5s. 0d. a ton, as compared with a price of £4 17s. 0d. just before the war. Straw sales assumed considerable importance at a total sale value of £3,312, which was not far short of the total sale value of the beet crop. The average price realised was £3 5s. 0d a ton.

Seeds and Fertilizers.

There is little point in stating in detail the various quantities and types of seeds used on these farms, nor is it necessary to distinguish between seeds purchased or home-grown. The total amount spent by these 118 farmers on purchased seeds of all kinds, including grass seed, amounted to £16,126, which is equivalent to £137 per farm. Omitting permanent grass and rough grazings, the purchased seed bill amounted to 28/- per acre, as compared with 12/- before the war.

The bill for fertilizers, including lime, amounted to £17,920 after deducting subsidies. This bill is equivalent to £152 per farm and to 12/- per acre of crops and grass, including permanent pasture but excluding rough grazings, and this figure may be compared with 4/4 per acre for 1938/39.

Costs of Implements and Repairs.

The first cost of using implements on the farm consists of the actual wear and tear which has to be made good by repairs. In accountancy, however, this cost is increased by the method of including arbitrary allowances for depreciation and obsolescence. To this again must be added the expenditure upon fuel used by the implements and the cost of vehicle taxes and insurances. It will, perhaps, be clear if the total cost of implements as outlined is now examined item by item.

The 118 farms possessed implements to a total value of £75,593 at the beginning of the year 1941/42, which is equivalent to £650 per farm, as compared with £520 before the war. The calculated depreciation during the year on their total value amounted to £14,880, equivalent to 8/11 per acre. To this amount must be added the cost of repairs, totalling £14,974, the cost of fuel amounting to £13,831, and taxes and insurances amounting to £2,303. The combined result is a bill of 27/8 per acre of crops and grass, and this may be compared with 17/6 per acre before the war.

There is no doubt that the increased number of tractors has contributed largely to the higher implement cost per acre. Whereas in 1938/39, 2 farms out of 5 possessed tractors, 3 out of 4 possessed them in 1941/42. The net result of the increase in the number of tractors is that there is now on these farms an average of one tractor to every 88 acres of arable land or one to every 230 acres of crops and grass. In the year before the war the figures were one tractor to every 120 acres of arable or one to every 510 acres of crops and grass.

Milking machines were found on 37 of the 118 farms, which is a proportion of 1 in 3, as compared with 1 in 4 just before the war.

Miscellaneous Items of Expenditure and Income.

Closely connected with the cost of implements is the bill incurred by these farmers on account of haulage and transport, which in total amounted to £3,840. The only other appreciable item of expenditure is that for veterinary services and medicines which altogether amounted to £2,028, equivalent to £17 per farm; this bill has remained fairly stationary during the past four years.

On the income side reference must be made to a few miscellaneous points. The ploughing subsidy amounted to £2,832. Farm produce consumed in the households of these farmers totalled £5,724, equivalent to £49 per farm. The rental value of the farmhouses amounted to approximately £2,580, averaging £24 per annum or slightly under 10/- per week. Cottage rents received in cash by these farmers amounted to £1,632.

Conclusion.

The chief purpose of this article has been to analyse and summarise the farm account data, which has kindly been supplied by farmers co-operating with the University in the Farm Management Survey.

The report does not pretend to represent the economic position of farming generally, although since a large number of comparisons have been made between the position of these 118 farms from year to year the report does establish certain facts and trends, which are capable of being applied in general terms to the agricultural industry as a whole.

REPORT ON ADVISORY WORK, 1941-1942.

The Advisory Service during 1941-42 has been very fully employed in contributing to the increase in food production and in furthering plans for the more effective utilisation of agricultural land. Both objectives have required much emergency work from advisory workers who have been called upon for technical assistance by the Ministry of Agriculture, the Agricultural Research Council, Ministry of Food, County War Agricultural Executive Committees and other organisations. The number of enquiries received from farmers and other members of the public has continued to rise and the total has reached a new high level at 10,352, an increase of 1,990 over 1940-41.

These enquiries are classified under the following headings :—Agriculture and Agricultural Chemistry, Dairy Bacteriology, Agricultural Economics, Veterinary Science, Cider, Cider Instruction, Fruit Products, Pomology and Vegetable Culture, Horticultural Chemistry, Economic Entomology, Economic Mycology, Insecticides and Fungicides, Domestic Preservation of Fruit and Vegetables, and Willows. The figures below refer to thirteen subjects, three at Berkeley Square and ten at Long Ashton. Figures for the preceding five years are also given for comparison.

ENQUIRIES SUBMITTED TO THE DEPARTMENT 1937—1942.

	Year ended September 30th.					
	1937	1938	1939	1940	1941	1942
Gloucester (including Bristol)	1730	1775	2264	1965	2491	2676
Hereford	275	337	556	182	196	729
Somerset	1118	1459	1117	1403	1479	2039
Wiltshire	1007	1328	1586	970	1410	1372
Worcester	360	520	677	656	1010	1506
Other Areas	1963	1813	1516	2686	1776	2030
	6453	7232	7716	7862	8362	10352

The main features accounting for changes are large increases in Agriculture and Agricultural Chemistry (+ 510), Veterinary Science (+ 273), Dairy Bacteriology (+ 205), Economic Entomology (+ 93), Economic Mycology (+ 127), Pomology and Vegetable Culture (+ 156), and Horticultural Chemistry (+ 89). In Domestic Preservation of Fruit and Vegetables there is a decrease of 191, accounted for by the smaller number of enquiries concerning the use of "Campden" (sulphur dioxide) Tablets.

The Agricultural Officer and Adviser in Agricultural Chemistry reports on a great increase in the number of soil samples received for analysis, approximately 7,000 being dealt with in the year. Since most of the first-class land in the Province is now under the plough, the samples submitted

were from the poorer fields where analysis commonly revealed deficiencies of one or more of the essential nutrient elements.

In view of the need for encouraging the use of ground limestone and waste limes, new liming materials were investigated, including magnesian limestone, of particular value for the magnesium-deficient areas in the Bristol Province. Experiments have also been made on the utilization of new phosphatic fertilizers. The silage-making campaign was continued and the use of potatoes in silage mixtures was explored. Flax variety trials and manurial experiments on flax have been extended.

The Advisory Dairy Bacteriologist has been placed in charge of the organization, within the Province, of the National Milk Testing and Advisory Scheme. Four area supervisors have been appointed and 103 testers licensed. The output of half the milk producers in the Province is now tested under this Scheme. By applying a standard rejection test to milk arriving at the creamery platform, it has been found possible to segregate the milk of poor keeping quality from the bulk supply. In addition to the National Scheme, the County Milk Testing and Advisory Schemes for Wiltshire, Gloucestershire and Worcestershire have been successfully maintained.

The cost of milk production throughout the year has been investigated by the Agricultural Economics Section. Progress was also made with the Farm Survey and the Farm Management Survey. A scheme for calculating costs of production of wheat, pigs and poultry was inaugurated under the title of Enterprise Cost Studies.

In Veterinary Science, the Investigation Officer reported a marked increase in enquiries concerning cattle diseases. Parasitic gastritis and enteritis continued to cause losses among calves, sheep and goats. Blood samples from fowls submitted during the year totalled 37,456 and analysis of the findings showed that 4.2% of the birds tested were carriers of Pullorum disease. Half the disease outbreaks investigated among chicks were due to this complaint.

The Advisory Entomologist notes that enquiries concerning insect pests of agricultural crops show a marked increase, particularly in the area served by the Evesham Field Laboratory. The team for wireworm survey was strengthened and the work extended. The Research Entomologist has given much assistance to the Supplies Branch of the Ministry of Agriculture and to the County War Agricultural Executive Committee in the provision of spray machinery and the organization of contract spraying. At Long Ashton, Spray Officers for Worcestershire and Gloucestershire were trained and courses of instruction in spraying were given to successive teams of members of the Women's Land Army.

The Plantations Officer has advised the Bristol City Council in its Growmore Campaign and supervised the maintenance of six demonstration allotments in the city and three at Long Ashton. Some advisory work in connection with school gardens in Wiltshire was also undertaken.

In Economic Mycology special attention was given to Potato Blight control and cereal seed dressings. The adviser maintained close touch with the County authorities by serving on technical Sub-committees in Worcester-shire, Gloucestershire and Somerset. The Field Laboratory at Evesham was

of particular value in serving the fruit and vegetable growers of that area, where diseases of onions and of outdoor tomatoes were the subject of numerous enquiries.

In Horticultural Chemistry special attention was devoted to diagnoses and remedies for failures in farm and garden crops resulting from soil deficiencies. Potash deficiency was found to be the most serious limiting factor to production on new allotment sites. Manganese deficiency occurred at several centres in the Province and failures of sugar beet due to boron deficiency were investigated in the Ross area of Herefordshire. Manurial trials were continued on vegetables in the Evesham area and on carrots in Somerset, Worcestershire, Herefordshire and Wiltshire.

The increase of enquiries in the Fruit Products Section arose mainly from the initiation of special schemes for the preservation of fruit and vegetables, in particular the production of treacle and pomace from carrots. The very heavy crop of plums in 1942 led to the adoption by the Ministry of Food of a large-scale trial in Kent of the Long Ashton SO_2 Cold Process of bulk preservation. The trial was under the technical control of the Fruit Products Officer. Close co-operation with the manufacturers of black currant syrup and of rose hip syrup has been maintained.

The Instructress in Domestic Preservation continued special courses in fruit and vegetable preservation both at Long Ashton and in the University Department of Botany.

The increased demand for basketware has stimulated the planting of willows. Lay-outs for beds were prepared by the Research Entomologist to provide for the use of modern power equipment to secure efficient cultivation and pest and disease control. At the request of the Ministry of Agriculture a survey of the Somerset osier beds was carried out.

Staff Changes and Appointments.

Agriculture and Agricultural Chemistry.

Appointments :—Miss L. Grenfell, B.Sc., Fieldman, Land Fertility Scheme; Miss M. Bottomley, B.A., Fieldman, Survey of Fertiliser Practice.

Resignations :—Mr. F. J. Marshall and Miss W. F. G. Smallwood, Fieldman, Land Fertility Scheme.

Dairy Bacteriology.

Appointments :—Miss M. S. Sellers, N.D.D., Miss J. C. C. Faill, N.D.D., Miss D. I. Mayes and Miss M. Johnson, B.Sc., Area Supervisors, National Milk Testing and Advisory Scheme.

Agricultural Economics.

Appointments :—Miss P. Brice, Recorder, National Farm Survey; Mr. H. Tilley and Mr. J. T. Welberry, Book-keepers (Economics).

Resignation :—Miss E. Alder, Recorder, National Farm Survey.

Economic Entomology.

Appointments :—Mr. H. W. Miles, D.Sc., as Advisory Entomologist, Mr. J. G. Mayor and Mrs. M. Miles, M.Sc., as Technical Assistants.

Appointments for the Wireworm Survey were as follows :—Miss E. L. Britton, B.Sc., Miss C. M. Duthoit, B.A., Miss M. E. F. Jones, B.Sc., and Mr. A. J. Lloyd, Ph.D., as Team Leaders ; Miss M. J. Haddock, B.A., as Senior Field Assistant ; and Miss B. N. Smith and Miss E. O. Murphy as Field Assistants.

Resignations :—Mr. C. L. Walton, Ph.D., Advisory Entomologist. Mr. C. H. Hoddell (appointed Spray Officer to Worcs. W.A.E.C.), Mr. N. G. Morgan, B.Sc. (seconded as Spray Officer to Glos. W.A.E.C.).

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